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SOIL SURVEY: A BASIS FOR LAND UTILIZATION IN BRITISH COLUMBIA[1]

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In order that one may get a clear picture of the use of the soil survey as a basis for determining the proper utilization of land in British Columbia, it may perhaps be wise at the outset to recall the climatic conditions and topographic features as they exist in the Province. British Columbia is a region of extremes. Its numerous mountain ranges extend for the most part in a north-westerly and south-easterly direction. Agricultural lands are to be found at elevations varying from sea level to 4,000 feet and over. The mountain ranges and prevailing winds exert a tremendous influence on both the amount and distribution of precipitation. Annual rainfall varies from less than 10 inches in some regions to 200 inches and more at other points. The differences are great, even within a few miles, at approximately the same elevation. In regions of low precipitation the rainfall is fairly well distributed throughout the year, while in regions of a higher fall, 30 inches or over, it occurs largely during the winter months with relatively little throughout the growing season. Shallow and deep phases of glacial, volcanic, alluvial and organic soils are found in practically all these climatic regions.

The various factors enumerated above exert a tremendous influence not only on crop production, but on the soil itself. In the conduct of a soil survey the logical procedure is obviously to associate these factors with the survey so far as is possible. Since the soil profile in the case of a mature soil presents an excellent picture of the soil-climate interrelationships, it appears highly advisable to base the survey on a profile study. Such a procedure insures a better understanding of soil characters and peculiarities in any climatic region, and is therefore particularly desirable in the case of high-priced lands or those devoted to specialized crops.

For practical purposes many extensive areas are being grouped without the use of a detailed survey. For instance, some twelve years ago the Provincial Department of Lands undertook a forest survey which involved among other things the mapping of areas suitable only for reforestation. A soil surveyor accompanied the party, and as a result in many regions the boundaries between forestry and agricultural lands have been defined, some 12,000,000 acres having already been definitely prescribed as forest

[1] Presented at the annual meeting of the Soils Group of the C.S.T.A. at Macdonald College, P.Q., June 26 and 27, 1934.

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reserves. This work is continuing. It is hoped that a similar broad general type of survey may be extended at the first opportunity into the agricultural field itself in such a way as to map the areas which should be reserved for grazing purposes. Thus we would have our forest regions, grazing areas, and cultivatable lands defined.

The official designation of the foregoing areas, based on a general survey associated with a detailed soil survey of arable lands, will obviate certain serious difficulties with respect to logical development of rural British Columbia. First, forest and grazing areas will be preserved to advantage in that settlers will not be permitted to "prove up" on relatively small acreages suitable for general agriculture which may lie within typically grazing or forest regions. The former obviously must be reserved to provide winter forage for range stock. Second, under existing conditions hundreds of families occupy lands which are too poor or too small in area to return a fair living. Revenue arising from such agriculture will not support schools, roads, and other public services necessary for a desirable standard of citizenship. Utilization of submarginal lands is an outstanding illustration of our present misuse of land. Third, the detailed survey will define arable lands in both settled and unsettled districts and will bring forcibly to our attention the numerous soil problems which are now existent or may become so with settlement. Some of these will be referred to more or less generally when giving consideration to the detailed soil survey.

SOIL SURVEYS IN BRITISH COLUMBIA

While forest surveys have been under way for some years, the detailed soil survey was instituted for the first time in British Columbia in 1931. Special demands have so far determined the districts surveyed and to date they have been confined entirely to semi-arid regions. Soil maps of eight different districts have been prepared covering over 65,000 acres in all. Pits have been used almost exclusively for the study of soil profiles, and these, along with the extreme variation in the soil where agriculture is highly specialized, have necessitated a slow but accurate prosecution of the work. As familiarity with the soils of the region increases, not only may the number of pits required be considerably reduced and the rapidity of the work thereby appreciably increased, but also, the knowledge thus acquired may be projected and used to advantage in the subsequent survey of other areas. Thus it is believed that as the survey proceeds the acreage covered will be speeded up without any sacrifice in accuracy.

Progress in the conduct of the survey will be much more rapid, too, in humid regions where in the case of large areas, the soils are immature and show no profile characteristics. In such cases the soil auger will be sufficient for subsoil studies and will for specific reasons largely substitute for the pit on soil types where profiles are clearly defined.

We are asked on occasion why, for subsoil studies, an auger is not just as satisfactory as the digging of pits. It probably is when one is surveying an area devoid of any profile characteristics. When surveying regions wherein the soils have distinctive profiles, the pits are necessary in order that one may study the various horizons in detail and secure valuable information on soil-climate interrelationships. Through this procedure also, one is able to correlate soils, to some extent at least, with those of

the European countries where similar practices have been followed, and thereby benefit locally from the intensive study to which corresponding soils of Europe have been subjected. There are other points, of course, relative to the use of pits, but space does not permit their discussion on this occasion.

The surveys to date have been confined to areas already under cultivation or to those thought to have agricultural possibilities other than for grazing. In some districts already under irrigation, seepage presents serious difficulties; hence in the survey of areas for which irrigation is proposed, the surveyor gives particular attention to the possibility of its occurrence and probable control. While he is obviously unable to forecast control measures in all instances, his report will be invaluable in coping with the problem should it develop. The probability of alkali becoming a problem upon the addition of water also receives careful consideration.

Elevation, topography and relationship of arable lands to adjacent mountains are extremely important. Elevation may be a factor influencing soil type, but it at the same time determines the suitability for specific plant species. Topography is obviously often the lone factor determining the disposition of land. It has at the same time a tremendous influence not only on irrigation and irrigration problems, but also on ease of cultivation and cultural practices. The proximity, location and height of mountains exert such an influence on the adjacent arable lands, in many instances, that they must be given consideration in compiling the report. Thus, in the preparation of our soil maps mountains are indicated where necessary, contours are transferred to it when available, but unluckily a very small proportion of the Province has been surveyed topographically. If such data were available it would add immeasurably to the value of the map. We have felt it necessary in some instances to determine grades, transfer these to the soil map in per cent, and indicate direction of slope by means of arrows. This takes time of the field men which should otherwise be devoted to the soil survey itself. It is to be hoped that topographic maps may be available in the not too distant future.

USES OF THE SOIL SURVEY

Upon correlating survey findings with meteorological data, latitude and elevation, one is able to arrive at a reasonable conclusion as to the suitability of the soils for specific purposes. For instance, one can determine with some assurance whether or not a particular area is suitable for irrigation; whether or not there is likely to be a seepage problem; if so, whether or not it can be readily controlled. One irrigation district which has been surveyed showed 83.8% of the arable land to have no moisture holding capacity. Many of the orchards in this area disappeared following the drought of 1929, when the supply of irrigation water well nigh failed. These soils were coarse in texture, shallow and underlaid by sand, gravel and small boulders. They could be maintained in production providing unlimited supplies of water were available. In such a case, however, seepage would have to be controlled and heavy leaching losses taken into consideration, both of which would naturally involve additional expense.

We have soils and climates suitable for a great variety of specialized crops. Knowledge as to the possible extent of these areas is entirely

FIGURE 1. Orchard land in the foreground with grazing country in the distance. Vernon District, British Columbia.

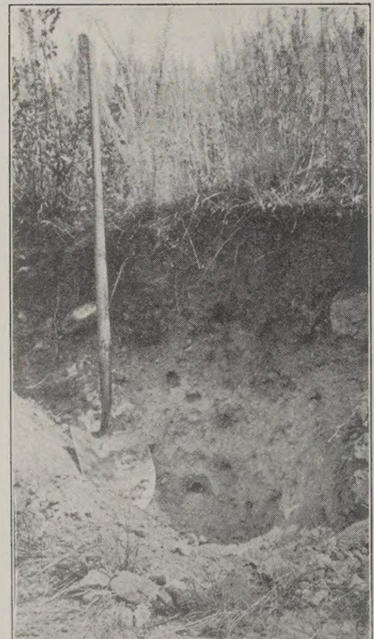

FIGURE 2. Black sandy loam, shallow phase; typical of many North Okanagan orchard soils, British Columbia.

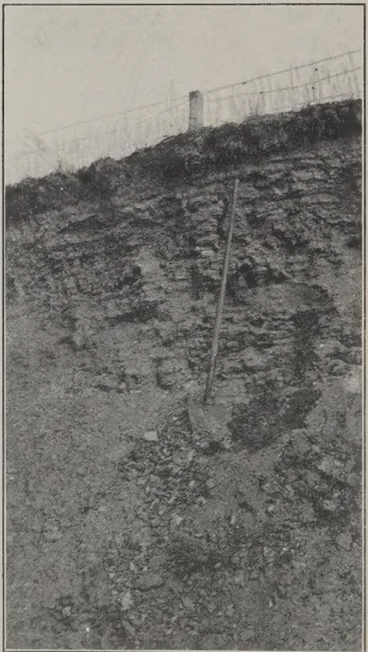

FIGURE 3. A heavy clay profile; typical of some North Okanagan soils, British Columbia.

empirical at the present time, but it is hoped that through the survey and supplementary studies one may be able, with a fair degree of accuracy, to estimate acreages in the various agricultural districts suited to each of the specialized crops which British Columbia is capable of producing. Or, on the other hand, one may simply derive from the survey report figures on acreage suitable for agricultural purposes in any district or region.

The survey and the chemical analyses associated therewith give one a lead as to some of the problems associated with certain soils, if they are not already known, and, through the mapping of types, the distribution of these problems. For instance, there is the problem of heavy leaching losses from some of the soils in humid regions, and there is the possibility of alkali developing in some other areas. Alkali is already recognized in some localities and the extent of these areas can be determined more economically in conjunction with the survey than at any other time.

Results obtained from fertilizer experiments during the past twenty years have served as valuable guides for the use of commercial manures, but we have not been able to make maximum use of the data, simply for the reason that we do not know the extent to which the results of each experiment are applicable. A soil map would enable a much broader application to be made of data relating to fertilizers and would ensure a more accurate interpretation being placed on such data.

Much use is being made of the survey to date, but it must be remembered that the survey itself constitutes only the ground work as it were, and is not the end in itself in so far as either theoretical study or practical applications are concerned. If the findings are to be carried to a logical conclusion and the maximum value obtained therefrom, the soil map and associated data should be used as a basis for systematic study of the soil types mapped. Field and laboratory studies should be undertaken to ascertain how each of these types may be handled to best advantage, what procedures must be adopted to overcome weaknesses, how their strength may be utilized to best advantage, and for what specific types of agriculture they are best adapted. To date the surveys have not been used to any appreciable extent for such purposes, but it is our hope that this condition will be only temporary.

A soil survey is, in our opinion, fundamental to a planned and progressive policy for agricultural development along sound economic lines. The survey, we believe, has demonstrated its value in this regard, and already the practice of conducting such a survey before any extensive development work is undertaken, has been adopted. While the soil survey is not infallible, yet its utilization should eliminate the enormous agricultural waste which comes from attempts by courageous but misguided pioneers to develop farms in forest regions, upon range or upon submarginal lands in agricultural areas, and should reduce the number of disappointments with respect to the use of irrigation.

Our settlement policies, our fertilizer experiments, our general soil investigations and our studies on specific soil problems, all with an eye to a more profitable agriculture, should be based essentially on the soil survey. With this systematic organization our objective should be attained both economically and effectively.

No one can determine, or even estimate, the agricultural possibilities of British Columbia without a detailed knowledge of its soil resources. Since this knowledge can be obtained most effectively in conjunction with, or following the soil survey, it would appear to be highly desirable to give it a prominent place in any agricultural program.

Résumé

La classification des sols: une base pour l'utilisation des terres en Colombie-Britannique. D. G. Laird et C. C. Kelley, Université de la Colombie-Britannique, Vancouver, et le Ministère de l'Agriculture de la Colombie-Britannique, Victoria, C.-B.

Nous sommes d'avis que la classification des sols doit être une mesure préliminaire dans tout programme bien conçu tendant à developper l'agriculture sur des bases saines et économiques. Nous croyons que l'utilité de cette classification a été amplement démontrée; on a même pour règle aujourd'hui d'établir une classification avant d'entreprendre des travaux de développement tant soit peu importants. La classification des sols n'est pas infaillible, mais son emploi devrait supprimer les pertes immenses résultant des tentatives faites par des pionniers courageux, mais mal conseillés, pour ouvrir des fermes dans des régions qui auraient du rester en forêts, en herbages ou en pacages, et devrait réduire les déceptions qui suivent souvent l'emploi de l'irrigation. Nos programmes de colonisation, nos essais d'engrais chimiques, nos recherches générales sur les sols et nos études sur les problèmes spécifiques du sol, qui ont tous pour but de rendre l'agriculture plus lucrative, devraient être basés essentiellement sur la classification des sols, qui seule peut nous permettre d'atteindre notre but pleinement et sans frais exagérés.

REMARKS ON THE UTILIZATION OF THE SOIL SURVEY AND SOME DATA REGARDING THE SOILS OF SASKATCHEWAN[1]

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The total area of the Province of Saskatchewan is given as 251,700 square miles (*1*). About 100,000 square miles of the southern part of the province are well developed agriculturally. Along the northern fringe of this area new settlements are being established. They are for the most part situated in heavily wooded regions, where the problems of drainage, clearing the land, and somewhat low soil fertility are entirely different from the problems encountered by the pioneer settlers of the prairie to the south. Still further to the north stretches the forested area with its more numerous swamps and lakes. The northeastern section of the province is part of the pre-cambrian shield, and in this region the soils are likely to be shallow, exposures of bare rock are numerous, while lakes and rivers occupy a large share of the area. It is possible that the extreme northeast tip of the province touches the barren lands.

Practically all of the well settled area of the Province has been covered by a reconnaissance soil survey. The survey has necessarily been of an extensive nature but it is proving suitable to the type of agriculture of the province. The field work is nearing completion so that publication of the final report and map could be undertaken shortly. Tentative maps on a scale of six miles to the inch with accompanying legends have already been made by hand.

THE SOIL ZONES AND THEIR AREAS

Three distinct soil and climatic zones are to be found in the province and have been fully described by Joel (*2*); hence they do not require detailed descriptions in this paper. They are the plains, the park, and the wooded zones. Transitional between the plains and park zones is the dark brown soil belt, and there is also a transition area of a discontinuous nature between the park zone and wooded area. The park zone has been subdivided into deep and shallow park. Besides the soil differences of the different zones, there are, of course, climatic or vegetational differences or both. Between the plains and park zones both climatic and vegetational differences are easily noted but between the park and wooded zones the difference in soils seems to be chiefly due to the influence of vegetational factors. All zones have been practically completely mapped by the survey except the wooded zone, which has been only partially mapped at its southern border. It is probably the most extensive of all the zones. The areas of the zones as already mapped by the survey are as follows:

Zone	Area in sq. miles	Percentage of area surveyed
Brown Plains	30,725	32.6
Transition, dark brown prairie plains	29,240	31.1
Park: Shallow dark park	22,550	23.9
Deep dark park	2,915	3.1
Wooded grey soils (incompletely mapped)	8,750	9.3
Total	94,180	100.0

[1] Presented at the annual meeting of the Soils Groups of the C.S.T.A. at Macdonald College, P.Q., June 26 and 27, 1934.
[2] Soils Department.

With the recognition of the major soil zones of the province and their differences in climate and natural vegetation, there is a better basis for the recognition of broad differences in agricultural adaptation. The study of such areas as the Cypress Hills where several zones are found in close proximity to one another, due to sharp variations in elevation, served in some measure to emphasize the need of considering this question.

Some of the broader differences in the agricultural adaptation of the soil zones are quite generally recognized. The better soils of the brown and dark brown plains are known to be well suited to the production of high quality wheat. Great fluctuations in yield are experienced from one season to another but on the average the yields are good for the better soil types. In the park belt wheat may be grown quite successfully but with a distinct tendency towards lower quality as measured by the protein content. Coarse grains do exceptionally well and forage crops are generally successful, especially so on the deeper park belt soils. In the wooded zone, where the typical grey bush podsolic types occur, a different problem is to be met in that these soils are generally low in fertility. Grain yields are often low although moisture conditions are usually good. A rotation including clovers, with the addition of phosphate fertilizers, has given excellent yields on these soils (*3*).

These few illustrations serve to make apparent some of the broader general differences in agricultural adaptation between zones. It seems likely that these variations will become more pronounced in the future as the agriculture of the province becomes older and more stab lized. The prairies, no doubt, will remain chiefly grain growing areas because of the general suitability of the soil and climate for grain production, while livestock production may become a more common type of agriculture in the park and wooded zones where forage crops can be successfully produced.

FIGURE 1. Cultivated field blowing into dunes and burying road. There are many abandoned farms in this vicinity.

THE UTILIZATION OF THE SOIL SURVEY REPORTS

A remark often heard while carrying on the work of the soil survey is, "It is a good thing but it ought to have been done forty years ago." The inference is that the value of the work is very greatly diminished because the information was not available to the first settlers. It is quite true that in certain areas land has been cultivated that would have been better left undisturbed. Such mistakes have caused a great loss in both public and private capital investment and will occasion further losses. Probably an even more unfortunate phase of this situation is the wasted years and broken spirit of the settlers who found only through experience that they were encumbered with land unsuitable to the type of agriculture they had hoped to practice. The soil survey can be of great use in dealing with this problem inasmuch as it serves as the basis for any agricultural policy which may be developed to deal with these lands.

The present reconnaissance survey has already proven useful to workers in several fields of agricultural research in this province, although only a few tentative copies of the soil map have been made as yet. Entomologists, plant pathologists, agronomists and agricultural economists are among those who have found the map and related soil information a useful adjunct in their studies. There are phases of such problems as soil drifting, weed control and fertilizer practice which are specifically related to soil conditions, and in the study of them a knowledge of the soil should prove of first importance. An extension of the use of soil information in dealing with agricultural problems would seem to be highly desirable since there is little doubt that the soil relationships involved in some of these problems have not been given sufficient attention heretofore. It is as an aid to the solution of such problems that the soil survey is likely to have its greatest value. While the soil survey reports (*4*) already published have been useful to many agricultural workers, their use in the various fields of Extension work has been somewhat limited since the reports covered only

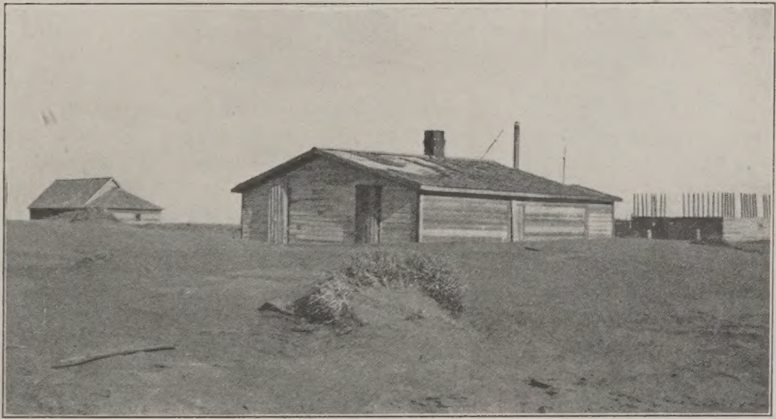

FIGURE 2. Abandoned farmstead on fine sand. A sand dune is forming in the farm yard and is threatening to cover the buildings. This is the result of cultivation of unsuitable soil.

small isolated areas of the province. However, when a map and report of the larger part of the settled area of the province are published, extension services of both public and private institutions should find them of considerable value. Certain private institutions, including banks, loan companies, and mortgage companies have been eager to obtain the published reports mentioned above, but it is probable that they were interested in them mostly because they could use the reports to assist in the valuation of land, rather than to assist in the solution of some of the problems concerned with production on the land. The maintenance of a proper harmony between the type of production practised on a farm and the type of soil upon which the farm is located should obviously be a prime consideration.

SOME DATA OBTAINED BY CLASSIFYING THE SOILS INTO GROUPS ACCORDING TO THEIR SUITABILITY FOR WHEAT PRODUCTION

Some interesting data are obtainable by classifying the soils mapped by the survey into: (1) best wheat lands, (2) very good wheat lands, (3) moderately good wheat lands, (4) fair wheat lands, (5) poor, and (6) very poor wheat lands.

The classification can be only approximate, of course, and is based more upon the combined judgments of the members of the Soils Department than actual statistical data of the productive capacity of the soils.

The results of such a classification give the following figures:

—	—	Approximate area in sq. miles
Best wheat land	7.1% of area surveyed	6,680
Very good wheat land	5.9% of area surveyed	5,560
Moderately good wheat land	16.9% of area surveyed	15,910
Fair wheat land	25.4% of area surveyed	23,920
Poor wheat land	18.5% of area surveyed	17,410
Very poor wheat land	26.2% of area surveyed	24,630

The area given for each group in the above table represents the combined area of a number of soil types. The area occupied by each type was determined directly from the soil map with the aid of a planimeter.

In brief, the tabulation of the soils of the province of Saskatchewan into the classes as given above indicates that for nearly half of the settled area of the province the land is not well suited to wheat growing. It should be pointed out that the land included in the "poor" and "very poor" classes includes the hilly, stony and sandy areas, and that only a moderate portion of these areas have been brought under cultivation. However, it is the farmer located on such lands who finds himself in a particularly distressing situation. In the case of soils classed as "very poor," it seems that ultimate abandonment and return of the cultivated land to natural grass as fast as nature will allow is the best solution. For some of the soils classed as "poor," there is a good possibility of adapting the type of agriculture to meet the soil and climatic conditions. This

adaptation is already being made by some farmers who are located on the lighter soils.

Reduced wheat acreage or practical abandonment of wheat production is a feature of the changing agricultural practices on such soils. This would seem to be wheat acreage reduction of a most desirable kind. So far, necessity has been the mother of the changing type of agriculture on the poor lands. Soil drifting, dry seasons, and weeds are some of the factors tending to force the adoption of new practices. The process of making such adjustments is only at its beginning. The rehabilitation of agriculture on lands unsuitable for wheat production is a problem involving considerable areas of this province and is one which will require the combined efforts of all those concerned with its well being.

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Résumé

Observations sur l'utilisation de la classification des sols et données sur les sols de la Saskatchewan. J. Mitchell et D. L. MacFarlane, Université de la Saskatchewan, Saskatoon, Saskatchewan.

La majeure partie de la région colonisée de la province de la Saskatchewan a été couverte par la classification des sols. Dans une région de ce genre, on trouve naturellement toutes sortes de sols, depuis ceux qui sont éminemment aptes à la production du blé jusqu'à ceux qui sont impropres à cette culture. Le cultivateur qui s'est établi sur des sols de cette dernière catégorie a de très grandes difficultés à surmonter. Il n'a pas encore été publié de rapports ni de cartes de cette classification mais les données obtenues ont déjà rendu de grands services aux investigateurs dans différents champs des recherches agricoles. Cette connaissance des sols pourrait être utilisée également dans l'étude d'un grand nombre de problèmes agricoles et il est vivement à désirer qu'elle le soit.

ORIGIN AND CHARACTERISTICS OF THE RED RIVER VALLEY AND REGINA PLAIN CLAY SOILS OF WESTERN CANADA[1]

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The black clay soil of Red River Valley in Southern Manitoba, and the brown clay soil of the Regina plain in Southern Saskatchewan are two of the most extensive and important soils in the Interior Plains region of Western Canada. The two soils are similar in some respects, because of a nearly common origin of parent materials, and differ in other respects owing to climatic variations. In connection with the utilization of the soils special problems are offered to the scientific agriculturist, for over large parts of both regions only scanty supplies of usable groundwater or of surface water are obtainable, and this prohibits live-stock farming on any large scale. Both soils are affected to some extent by soil drifting, and under the present system of farming this problem is likely to become more acute in the future. A question mainly of scientific interest is the classification of these soils in any world scheme of classification. Is the black clay soil of Red River Valley a tshernosem, a meadow (ground-water) soil, or a prairie soil having affinities with the podsolic group; and how should the brown Regina clay soil be classed? Are these terms applicable to the soils of the Interior Plains region of Canada? In this paper the problems associated with the utilization of the soils are not discussed or are only briefly referred to, as their solution is the work of the scientific agriculturist; the character of the soils both with reference to the parent materials and to pedogemic processes is described and their classification briefly discussed. The paper is offered as a contribution to our knowledge of the soils of the Plains region and is presented mainly from the geological standpoint; a thorough knowledge of the character of the soils is necessary in attempting to solve problems that are bound to arise in the future because of soil drifting and other conditions such as the scarcity in some areas of ground-water supplies.

THE RED RIVER VALLEY CLAY SOIL

Red River Valley is a nearly level plain drained by Red River flowing north into Lake Winnipeg, and by Assiniboine River coming from the west and joining the Red at Winnipeg. These streams and their few tributaries occupy comparatively narrow and steep-sided valleys, 20 to 50 feet deep. Large parts of the plain have no natural drainage and were formerly marshy in wet seasons, but have been drained for the most part by ditching. The plain is an ancient lake bed formed several thousand years ago during the melting away of the last ice-sheet. It has been modified to some extent since the lake was drained by stream erosion and by deposition from overflow of the streams. Assiniboine River overflows its banks in places nearly every year, but only twice since the earliest days of settlement has Red River overtopped its banks, once in 1826 and again in 1852. When the first settlers entered the region over 100 years ago,

[1] Published with the permission of the Director of the Bureau of Economic Geology, Department of Mines, Ottawa, Canada

[2] Chief, Borings Division.

the great part of the valley was found to be prairie and this greatly favoured pioneering. Forests grew mainly along the streams. The soil thus is a prairie soil. It is doubtful whether Red River Valley has been forested to a greater extent than at present at any time since the former lake was drained, for the clay shows no evidence of root penetration of former trees. As has frequently been pointed out, prairie vegetation has been favoured owing to prevention of natural regeneration through prairie fires and the effects of grazing animals. Prairie fires must have periodically swept the valley from end to end owing to the few natural fire guards and to the drying of the marshes in times of drought; and the grazing of the countless herds of bison that once roamed the Plains region must have had an important effect in preventing the spread of forests. That the rainfall or ratio of evaporation to rainfall is sufficient for the growth of forests is shown by the results of tree planting and the occurrence of extensive forests in adjacent areas that have the same rainfall or somewhat less.

The clayey part of the former lake basin on which the Red River Valley clay soil is developed, occupies a wide belt along Red and Assiniboine Rivers. Near the International Boundary, the belt extends 10 miles east of Red River and 20 miles to the west. It widens to the north, and on the latitude of Winnipeg, extends 20 miles to the east and 60 miles to the west along Assiniboine River. The area, approximately is 4,500 square miles. Surface and soil conditions vary somewhat in different parts, but over the greater part are fairly uniform. Small areas along Assiniboine River are subject to overflow in times of freshet, and there are in places undrained areas that are partly flooded in wet seasons and become dry in times of drought. In these areas there is no accumulation of peat at the surface; but in the northeast along the valley of Brokenhead River where flooding is more pronounced, peat has accumulated at the surface and soil conditions are markedly different.

Climatic conditions are those characteristic of an interior continental region; the winters are cold and the summers warm. At Winnipeg the mean temperature for January from 1885 to 1930 ranged from $-14.5°$ to $7.8°$ F., and for July from $61.4°$ to $72.3°$. Precipitation ranged from 13.76 inches (1917) to 27.19 inches (1898) and averaged nearly 20 inches. Precipitation in the southern part of the area near the International Boundary is slightly less than at Winnipeg. About 60% of the rainfall comes in April to July inclusive. The length of the growing season free from killing frosts ranges from 100 to about 140 days. Taking into consideration the relationship of evaporation to precipitation the climate may be classed as sub-humid, that is, intermediate between humid and semi-arid.

Ground-water conditions in the area are markedly influenced by the climate and by the character of the surface deposits overlying the bedrock. The surface deposits average over 50 feet in thickness and consist of stratified clays overlying boulder clay. Nearly impervious clay lies at a depth of 6 to 10 feet, the upper clay being more porous and containing sand and silt in its lower part. The lower clay acts as a seal for artesian water in the vicinity of Winnipeg and at other places. Owing to the high absorption properties of the soil and of the upper clay, a considerable part

of the rainfall passes downward and is held by the impervious clay below to form a source of ground-water for growing plants. The upper surface of the zone of saturation in the clay lies at a depth of 10 or 15 feet to above 40 feet. Wells sunk in the clay yield only small supplies, for seepage of water from the clay is extremely slow. The water has a marked temporary and permanent hardness and a fairly high proportion of soluble salts in solution. What proportion of the rainfall is absorbed by the soil is not definitely known but it must be fairly high for only in the poorly drained areas does water lie after heavy rains. There is a nice balance between rainfall, evaporation and absorption; a rainfall equal to that of the more humid region to the east would result in flooding large areas.

The soil formed in Red River Valley varies somewhat depending partly on whether it is developed on the alluvial clay along the stream valleys or on the lake clay, the former as a rule being a much deeper soil. A soil profile on the alluvial clay at Winnipeg is as follows:

1. Black humus stained clay showing columnar structure in places but for the most part breaking down into irregular lumps and eventually into a fine-grained granular mass. Slightly calcareous particularly in the lower part. Depth 12 to 14 inches.

2. Greyish-black clay showing poorly defined columnar structure, and irregular blocks separated by vertical shrinkage cracks. The black clay extends downward in long tongues into yellowish grey clay. Soft irregular masses of calcium carbonate up to one or two inches in diameter occur both in the black clay and in the grey clay which is somewhat sandy and silty. Maximum depth of the humus stained clay about 30 inches.

3. Yellowish-grey, granular clay that is highly calcareous. There is a marked accumulation of calcium carbonate in the lower six inches which is sharply set off from the underlying material at a depth of 4 to 4½ feet from the surface. The layer is a soft marly clay.

4. Light grey, stratified, calcareous clay.

In the lake clay areas, horizon No. 1 extends to about the same depth and is similar in character; horizon No. 2 is not so deep and contains comparatively little humus stained clay. There is a gradual transition downward into the parent material and a gradual increase in the concentration of calcium carbonate to a depth of about 3 feet but no very marked lime layer. The soil has been leached to some extent by downward passing surface waters but not completely, for even the surface soil in places is slightly calcareous.

The most striking features of the Red River Valley clay soil are its deep black color and the great depth—3 feet or even more in places—to which the dark color extends. The dark color is due to the presence of colloidal humus that is uniformly distributed through the clayey mineral part of the soil and whose formation has been greatly favoured by climatic and other conditions. Roots of prairie grasses and possibly in places vegetation buried beneath the silt deposited by flood waters formed an abundant source of organic matter that was readily altered to humus owing to the character and structure of the mineral soil. The calcareous character of the clay tends to produce a granular structure, and owing to its colloidal character shrinkage cracks readily develop in times of drought,

FIGURE 1. Red River Valley black clay soil, Winnipeg, Man.

thus causing aeration of the soil and alteration of the organic matter to humus, though the exact process by which alteration takes place is not known and may be highly complicated. In places the burrowings of animals may account for humus stained soil at a depth of as much as three feet, but at many places along Red River the black soil extends nearly to this depth in a fairly uniform layer and can hardly be accounted for in this way; more probably it is an alluvial soil. In the alluvial soil, however, the soil profile, as a rule, is a mature one owing to the infrequent periods of overflow of the stream.

It is doubtful whether the calcium carbonate layer should be considered as part of the soil profile owing to the depth at which it occurs, though it has been formed in part at least by downward leaching from the soil horizons.

How should the Red River Valley clay soil be classed in any world scheme of classification? It is not, at least for the most part, a meadow or ground-water soil, for it is best developed along Red River at places where there is good drainage both at the surface and underground; and except in the northeast there is no accumulation of peat at the surface even in the poorly drained areas. It has few if any affinities with the podsols of the more humid region to the east; it is a prairie soil that is only slightly leached and there is no translocation downward of the clayey fraction of the soil. Even the forested parts of the soil do not show these characters to any marked degree, and it seems doubtful whether the term podsol should be applied to any of the soils of the sub-humid Interior Plains region.

In some respects the soil markedly resembles the tshernosems or black earths as described by G. W. Robinson in his recent text-book on *Soils, Their Origin, Constitution and Classification*, and there is little doubt that it closest approaches this group of soils. In color and depth of the humus soil, in its structure and only partly leached character it resembles

the black earth soils. It differs in the absence of hard calcareous concretions and in the greater depth and, in places, poorly developed character of the calcium carbonate layer. The differences may be due partly to somewhat more humid conditions than are commonly found in black earth regions of north temperate latitudes and to differences in the parent materials.

THE REGINA PLAIN BROWN CLAY SOIL

A large area in Southern Saskatchewan that was formerly a lake bed, as was Red River Valley, is underlain by thick deposits of stratified clay on which a remarkably uniform brown clay soil is developed. The lake clays extend in a broad belt from Moose Jaw and Regina southeast nearly to Weyburn, and continue to the northwest along the South Saskatchewan valley. They occupy an area of several thousand square miles and form one of the most important of the agricultural belts in the province. In contrast to the nearly level surface of Red River Valley, much of the Regina clay plain is gently rolling but is generally smooth and free from stones and boulders. Sections show that the clay is extremely fine-grained and has been much disturbed by fracturing and distortion of the bedding which is only faintly visible because of the nearly uniform grain of the material. Possibly uneven settling of the highly collodial material after drainage of the lake resulted in unevenness of the surface.

Temperature conditions in the area, as shown by the Meteorological Service of Canada, are practically similar to those at Winnipeg, though the region has a general altitude of 1,800 to 1,900 feet above the sea, about 1,000 feet higher than Red River Valley. Precipitation at Regina has ranged from 8.04 inches (1886) and 8.54 inches (1917) to 22.67 inches (1890) and 22.53 inches (1927), with an average of about 16 inches. Conditions thus are markedly drier than in Red River Valley. Probably also the effects of drying winds are more pronounced because of the general absence of natural wind breaks, for nearly all the region is open prairie and has little relief.

Ground-water conditions in the Regina plain are markedly affected by climatic conditions and by the nearly impervious character of the lake clay. In places, for example near Regina, artesian water is found below the clay, but over large areas only scanty supplies of seepage water are obtained from the clay, and borings at depth find no supplies of usable water. In places sands and gravels occur at or near the surface, and in these water is commonly found but the sands are not very widespread. In the clay areas well borings generally show a shallow zone of saturation of the clay at a depth of 15 to 25 feet. Below this zone the clay may be nearly dry. Owing to the fine-grained character of the clay and its granular and jointed structure in the upper few feet, a large part of the rainfall is absorbed. In times of drought shrinkage cracks extend downward for several feet from the surface, and these aid in causing downward percolation of the surface water. In wet seasons and especially in spring, water may remain on the surface for some time in low-lying places and, as the great part of the plain has no natural drainage, there is comparatively little run off. The part of the rainfall that is absorbed extends downward only to shallow depths and forms the main source of water for growing plants.

The soil developed on the lake clay has been described by the Soil Survey of the Province of Saskatchewan under the name Regina Clay. The soil profile at Regina is as follows:

1. Greyish brown to dark brown clay showing columnar and irregular clod structure, eventually breaking down into a fine granular mass. Calcareous. Depth 12 to 15 inches.

2. Brown clay showing columnar and irregular contorted structure. Calcareous. Depth about 20 inches.

3. Light brown and grey clay showing concretionary calcium carbonate in small vertical and irregular masses. The upper limit of the calcium carbonate layer is a fairly definite line at a depth of $2\frac{1}{2}$ to 3 feet from the surface; the lower limit is irregular.

4. Poorly stratified light brown and buff clay much faulted and disturbed, and containing hard concretions of calcium carbonate and small crystals of gypsum. The effects of weathering in destroying the original structure of the clay extend to depths of 5 to 7 feet from the surface.

Like the Red River Valley clay soil, the Regina clay soil granulates readily under cultivation because of its high organic matter content in the form of collodial humus and its calcareous character. It is a heavier soil and more calcareous in the A horizon. Its most marked difference is the brown color rather than black. This seems to be due to the drier climatic conditions, for other conditions seem to be nearly similar, and over the drier parts of southern Saskatchewan all the soils tend to be brown whereas those in southern Manitoba have a much darker color. The organic matter content of the Regina clay soil, however, may be nearly as great as that of the Red River clay though the soil is not so deep.

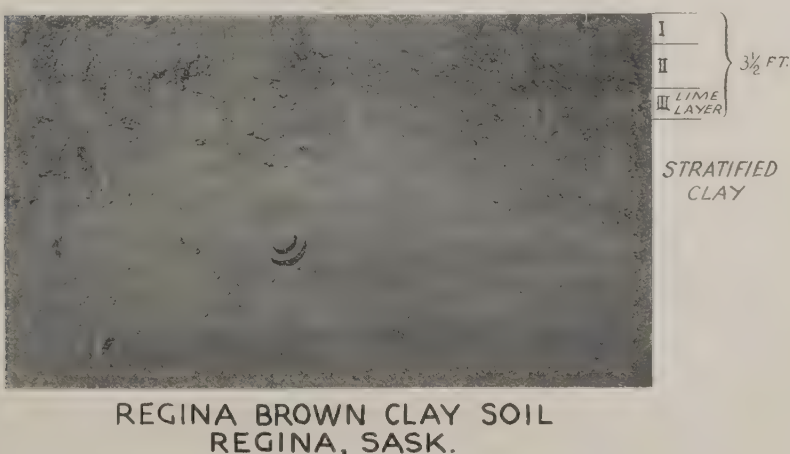

FIGURE 2. Regina brown clay soil, Regina, Sask.

The lime layer in the Regina clay is not well marked and lies at a considerable depth in spite of the dry climatic conditions. Its poorly marked character and the depth at which the small accumulations of calcium carbonate occur may be due partly to the colloidal character of the clay which causes it to crack badly in times of drought. Shrinkage cracks allow the surface waters to percolate downward to considerable depths, and these waters on evaporation deposit from the concentrated soil solutions calcium carbonate in the form of concretions and crystals of gypsum. In Southwestern Saskatchewan south of the Cypress Hills, where still drier conditions prevail, the lime layer is well marked and occurs at a depth of only about one foot from the surface. This illustrates the well known fact that the lime layer tends to approach the surface the more arid the climate; but variations may occur owing to the character of the soil.

In some respects the Regina clay soil resembles the chestnut-colored earths characteristic of semi-arid regions, but differs in the finely granular texture of the A horizon and the poorly developed character of the lime layer. These differences may be due to the collodial character of the clay, and to climatic conditions which may be regarded as on the borderline between sub-humid and semi-arid. It may be that because of the youthful age of the soils, geologically, typical tshernosems and chestnut-colored soils have not been developed in the Plains region of Western Canada.

SOIL DRIFTING

The causes of soil drifting are well known and have been well described in the University of Saskatchewan Soil Survey reports. High winds in times of drought coupled with dry farming methods which demand excessive cultivation of the soil and the granular character of the soil are the main causes. Various remedies have been suggested.

Both the Red River and Regina clay soils in spite of their heavy clay character are affected by soil drifting though not to the same extent as are the sandy soils. The very factor which renders the clay soils easily cultivated and highly productive, namely their finely-granular texture due to the high organic matter content in the form of humus, also renders them easily affected by soil drifting. Small rounded clay grains which at first glance appear to be sand grains drift before the wind, fill ditches and accumulate along fences and other barriers to form clay banks which when wetted by rains again become sticky clay. The finer material is taken into the air to form dust clouds that are carried far to the east by the prevailing westerly winds. In recent years the dust storms have become more frequent, and their extent far to the east in the spring of the present year caused widespread comment. Their effect on the Red River and Regina clay soils, however, is not so serious as might be supposed because soil drifting occurs only in times of drought, it affects only limited areas and the great depth of the humus soil prevents exposure of the subsoil. Nevertheless under the present system of farming, which because of climatic and other conditions seems a necessary one at least for large areas, soil drifting is likely to become more pronounced in the future and demands a remedy, though the intervention of a series of wet years may temporarily solve the problem. In connection with utilization of these soils most

investigators probably will agree that maintenance of their natural fertility is not a major problem. The soils are entirely different from those found in the more humid region of eastern Canada. Because of the sub-humid climate and mode of origin of the soils they have abundant stores of humus and of calcium and other salts in the soil solutions. The main problems are the proper utilization of the soils under the climatic and ground-water conditions that prevail, and the prevention of soil drifting.

Résumé

Origine et caractères des sols argileux de la vallée de la Rivière Rouge et de la plaine de Regina. W. A. Johnston, Commission géologique, Ministère des Mines, Ottawa.

Sous certains rapports, les sols argileux de la vallée de la Rivière Rouge ressemblent au groupe tshernosem de sols ou de terres noires, et les sols argileux de la plaine de Regina présentent quelques-uns des traits caractéristiques des terres couleur marron, mais pas tous. Ces deux genres de sols sont formés sur diluvium glaciaire; ils sont donc jeunes au point de vue géologique. Leur jeunesse, les différences que présentent les conditions climatériques et autres, peuvent expliquer pourquoi ils diffèrent des groupes bien reconnus de sols, comme les tshernosems et les terres de couleur marron.

SOIL TYPES OCCURRING IN THE RED RIVER VALLEY PLAIN[1]

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INTRODUCTION

The soils in the Red River Valley in Manitoba afford an excellent illustration of the great differences in soil type that may occur in associated soil profiles developed on the same parent material, and also of the varietal differences which may result within soil types (or groups) because of differences in parent material. The purpose of this paper is to present a brief description of this area; to point out the soil types (or groups) which occur,[3] and to indicate the determining factors responsible for the soil type variation. Incidentally the method of cataloguing or classifying the widely different soils, in the field-system of classification used is illustrated (*1*).

GENERAL DESCRIPTION OF THE RED RIVER VALLEY

The physiographic region locally defined as the "Red River Valley" in Manitoba is a wide expanse of grassland plain, occupying the basin of the glacial Lake Agassiz, through which the Red River flows from the International boundary to Lake Winnipeg. In the virgin condition this area constituted the northeastern portion of the grassland-plains immediately adjacent to the forest-region. In its northern and eastern portion there is now evidence of recent woodland invasion. The native vegetation at the present time may be divided into three types:

I. The tall-grassland-prairie formation.
II. The meadow-grassland formation.
III. The woodland vegetation, which may be sub-divided into:
  (*a*) the oak-elm-box elder woods of the river terraces.
  (*b*) the recent willow-poplar-oak woodland invasion of the meadows and prairies.

The distribution of these vegetative types is indicated in Figure 1.

The outstanding topographical feature of the so-called "Red River Valley" is its broad flat expanse of plain characterized by the general absence of macro- and meso-relief. In the southwestern portion which

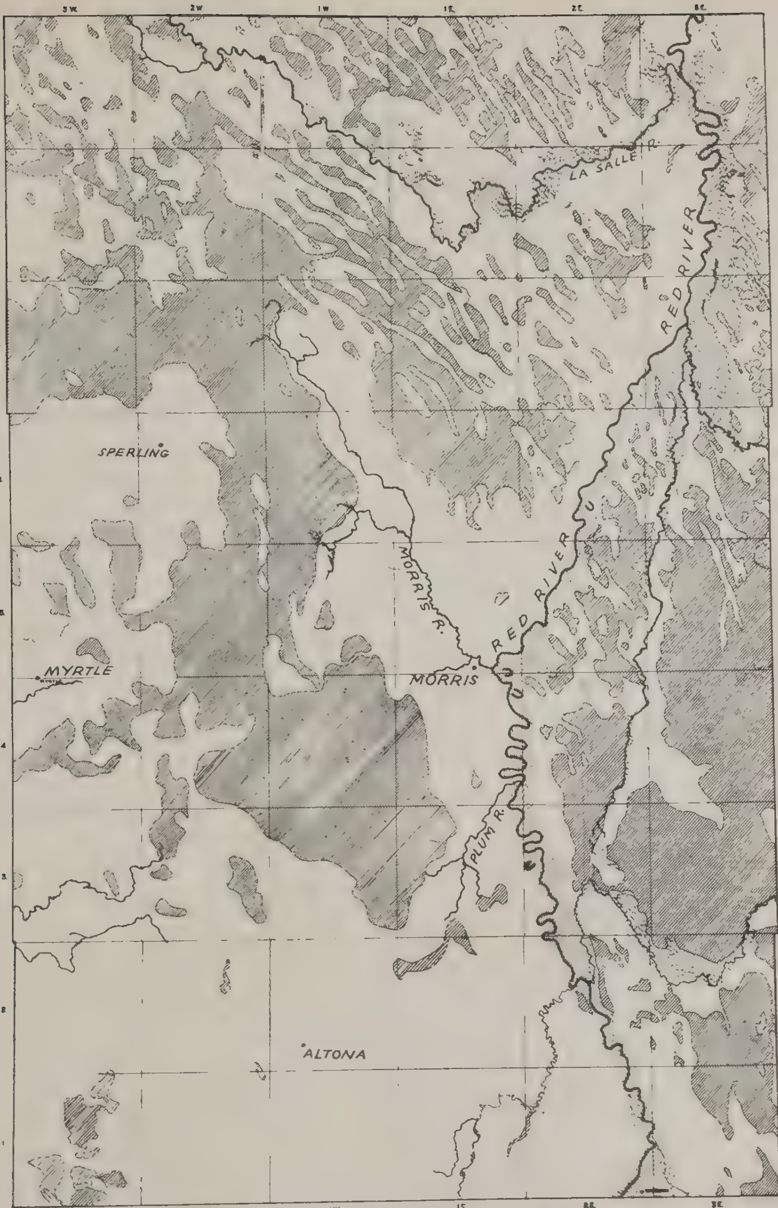
[1] Presented at the annual meeting of the Soils Group of the C.S.I.A. at Macdonald College, P.Q.; June 26 and 27, 1934.
[2] Soils Division, Department of Agronomy.
[3] The area which was covered by reconnaissance survey consisted of approximately 1,250,000 acres or 54 townships located in townships 1 (one) to 9 (nine) from ranges 3 (three) west to 3 (three) east of the principal meridian. The work was carried out by the Manitoba Soil Survey under the direction of the author as a joint project conducted co-operatively by the Dominion Experimental Farms, the Provincial Department of Agriculture, and the University of Manitoba.

Figure 1. Relationship of Soils and Native Vegetation (See opposite page)

Soils developed under moderately well drained condition, or in the process of transition to well drained conditions.

1. Phytomorphic and phytohydromorphic associates under prairie and meadow-prairie = unhatched.
2. Phytomorphic wooded associates under timber = broken vertical hatching.

Soils developed under poor natural drainage conditions; meadow-grassland vegetation = diagonal hatching.



SOILS DEVELOPED UNDER MODERATELY WELL DRAINED CONDITIONS OR IN THE NATURAL PROCESS OF TRANSITION

SOILS DEVELOPED UNDER POOR NATURAL DRAINAGE CONDITIONS

PHYTOMORPHIC & PHYTO-HYDROMORPHIC ASSOCIATES. PRAIRIE AND MEADOW-PRAIRIE SOIL.

PHYTOMORPHIC ASSOCIATES (TIMBERED SOILS)

HYDROMORPHIC ASSOCIATES (MEADOW SOILS)

lies above the 820 foot contour, the terrain has developed a young relief system with a fall of from eight to two feet per mile. The soils of the Altona Association occur in this portion; they are comparatively well drained. Below the 820 foot contour and throughout the central plain, however, the only relief, other than micro-relief, is *(a)* the very few canal-like channels cut by the rivers and streams into the easily eroded lacustrine sediments, and *(b)* the low wave-formed clay ridges found in the vicinity of the 780 foot contour. These low clay ridges run in a northwesterly and southeasterly direction; they correspond to the flat shore lines of Lake Agassiz during the Niverville stages. In the central clay basin (on which the soil of the Red River Association occurs) the altitudes above the river banks range only from 820 down to 765 feet; the fall in this portion varies from two to less than one-half foot per mile. Thus extensive areas of imperfectly drained soils are found, which, in the virgin condition, were covered with swales and broad shallow marshes, so that, in the Red River Soil Association typical well drained soils only occur adjacent to the stream channels, or on the above mentioned ridges (Figure 1).

Climate

The climate of the area as a whole is shown by the meteorological data recorded at Oakbank, Winnipeg and Morris, located on the central clay plain, and at Morden and Almassippi, located on the lighter textured area immediately to the west (*2*). The precipitation and temperature records available for varying periods of years are summarized in Table 1 and Table 2 respectively.

If the "precipitation effectivity index" (P/E)[3] and the "temperature efficiency index" (T/E) at each of these points are calculated according to the formula suggested by Thornwaite (*3*) the following values are obtained.

	P/E	T/E
Oakbank	54.0	35.67
Winnipeg	52.0	38.31
Morris	44.7	41.05
Almassippi	46.0	39.22

These values indicate that the climate is not uniform throughout. On the basis of Thornwaite's theory, black earth (chernozem) soils would be regional in the central and southern portion, but in the north eastern part of the "valley" a somewhat more humid climate is indicated.[4]

SURFACE GEOLOGY AND PARENT MATERIAL

The general surface geology of the area has been described by Upham (*4*) as lacustrine sediments. In the soil survey of the area the surface geological deposits were further subdivided into eight different soil parent materials, each having its own "association" of soils. The type of deposit,

[3]P/E index = summation of each monthly precipitation effectiveness $\sum^{12} 115\left(\frac{P}{T-10}\right)_n^{\frac{10}{9}}$

where P = monthly precipitation in inches, T = mean monthly temperature in F°, n = 1, and T values below 28.4° are taken as 28.4°.

T/E index = $\sum^{12}\left(\frac{T-32}{4}\right)_n$ where T = mean monthly temperature; n = 1, and T values below 32° are taken as 32°.

[4] According to Thornwaite's theory P/E values of 32 to 47 indicate the occurrence of chernozem soils and P/E values of 48 to 67 indicate the occurrence of prairie-earths.

TABLE 1.—MEAN MONTHLY, SEASONLY AND YEARLY PRECIPITATION IN INCHES AT LOCAL METEOROLOGICAL POINTS

	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Winter Ppt.	Summer Ppt.	Total yearly precipitation
Oakbank 1885-1928 44 years	1·10	0·92	0·99	0·84	1·19	1·65	2·04	3·16	2·84	2·04	2·32	1·46	5·03	15·55	20·58
Winnipeg 1874-1930 57 years	1·11	0·94	0·83	0·85	1·13	1·37	2·23	3·11	3·08	2·39	2·20	1·51	4·84	15·86	20·70
Morris 1916-1928 13 years	1·15	0·71	0·75	0·65	0·95	1·15	1·77	2·84	2·39	2·37	2·39	1·30	4·21	14·22	18·43
Almasippi 1907 1928 22 years	0·88	0·79	0·86	0·71	1·03	1·43	1·95	2·81	2·87	1·91	2·32	1·16	4·32	14·45	18·77
Morden 1885 1928 44 years	1·06	0·89	0·77	0·72	1·10	1·36	1·91	3·18	2·59	1·85	1·82	1·19	4·56	13·92	18·48

TABLE 2.—MEAN MONTHLY, SEASONAL AND YEARLY TEMPERATURE IN DEGREES FAHRENHEIT AT LOCAL METEOROLOGICAL POINTS

	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Winter mean	Summer mean	Yearly mean
Oakbank 1905 1928 24 years	23·95	6·39	−1·86	1·86	17·82	36·77	50·81	60·59	64·77	61·42	53·55	38·77	9·69	52·39	34·73
Winnipeg 1875-1930 56 years	21·88	5·38	−3·19	1·25	15·81	38·01	51·94	62·13	66·53	63·72	53·93	41·01	8·22	53·89	34·92
Morris 1916 1928 13 years	24·69	6·00	0·00	4·33	19·99	37·69	52·76	61·29	66·83	64·30	55·38	40·00	11·04	54·07	36·27
Almasippi 1916 1928 13 years	25·47	7·23	1·84	6·53	21·23	37·53	52·53	66·61	66·83	63·99	54·99	41·23	12·49	54·14	36·91
Morden 1905-1928 24 years	26·03	9·13	1·91	5·86	20·95	37·94	51·38	62·20	66·82	64·47	55·79	42·30	12·82	54·49	37·25

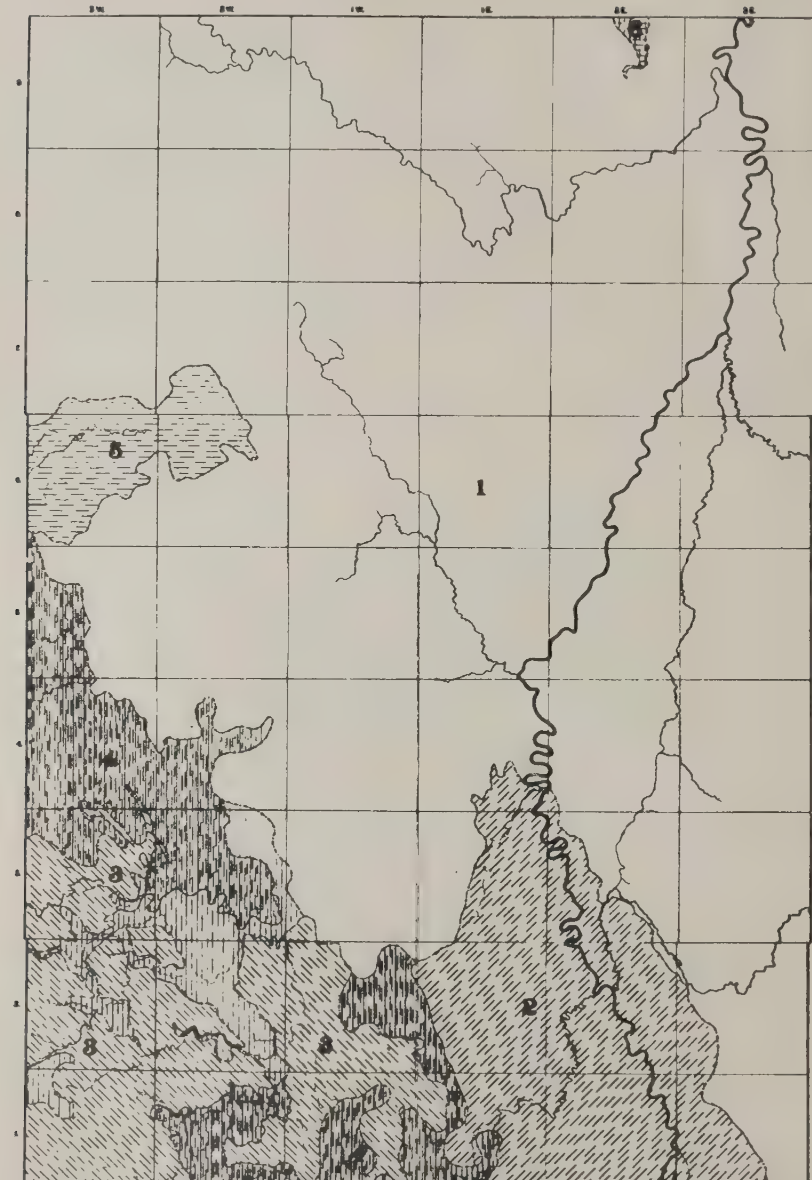


FIGURE 2. Distribution of Soil Associations

1. Red River Association developed on Lacustrine fine clay.
2. Emerson Association developed on Delta silt.
3. Altona Association developed on Sandy sediments.
4. Gretna Association developed on Cretaceous clay overwash.
5. Sperling Association developed on Stream outwash and levee.
6. Fort Garry Association developed on Mixed Lacustrine clay and dolomitic outwash.

or parent material, and the name given to the soil association occurring on each is given in Table 3. The distribution of six of these "soil associations" is shown in Figure 2. The other two soil associations are too small in area to be shown on a map of this scale.

DIFFERENCE IN SOIL DUE TO PARENT MATERIAL

The three major soil associations, namely the Red River, the Emerson, and the Altona comprise 82.69% of the area studied, hence the well drained soils (i.e. phytomorphic associates) of each of these three "associations" may be taken as constituting the typical regional soils developed respectively on heavy, on medium to heavy, and on light textured parent materials. These three phytomorphic "prairie-associates" are the normal soils developed in this area, under grassland, due to the influence of the "regional climatic" soil-forming processes; nevertheless, marked variations occur in their respective soil profiles. These variations are chiefly in the color and depth of horizons, in the texture and the structural aggregates, and in the organic matter and carbonate content. These variations are the result of the differential expression of the regional soil-forming processes on materials of different textural and minerological composition. Varietal differences due to parent material are seen also when either the meadow or other soil types (or groups) are compared. The major differences in the profiles of the Red River, Emerson, and Altona phytomorphic "prairie associates" are shown in Figure 3.

DIFFERENCES IN SOILS DUE TO ENVIRONMENT

Eight different morphological soil types (or groups) and a number of types are found in this area. However, all of the various morphological or genetic soil types do not occur in each "soil association." For example

FIG. 3. DIFFERENCES IN THE THREE CHIEF PRAIRIE SOIL PROFILES OF THE RED RIVER COMBINATION.

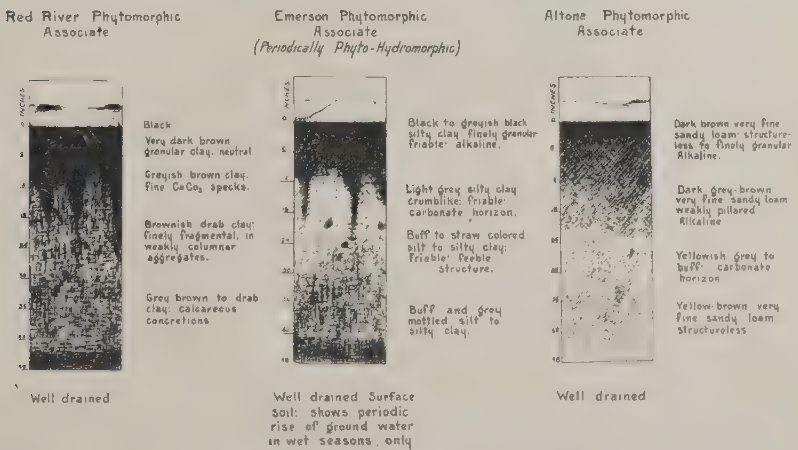


FIGURE 3. Differences in the three chief Prairie soil profiles of the Red River combination.

only two soil-types occur in the Altona and four in the Emerson "soil associations," but all of the eight types are found as "Associates" on the heavy clays of the "Red River Association." This latter "soil association" covers approximately two-thirds of the area studied. As this association contains all the morphological soil types of the area, it affords an excellent example of the variation in soils developed on the same parent material resulting from differences in native vegetation, drainage, position, etc. The number of soil types occurring in each of the "soil associations" and the method of cataloguing or classifying them in the field is presented in Table 3.

Space does not permit of a detailed description of the various soil profiles found; the key, however, to the soils of the "Red River Association" which have been developed on the fine lacustrine clays gives an indication of the soil variation and of the numerous soil types that occur on this parent material. The morphological differences of the five most important types are illustrated by the sketches in Figure 4.

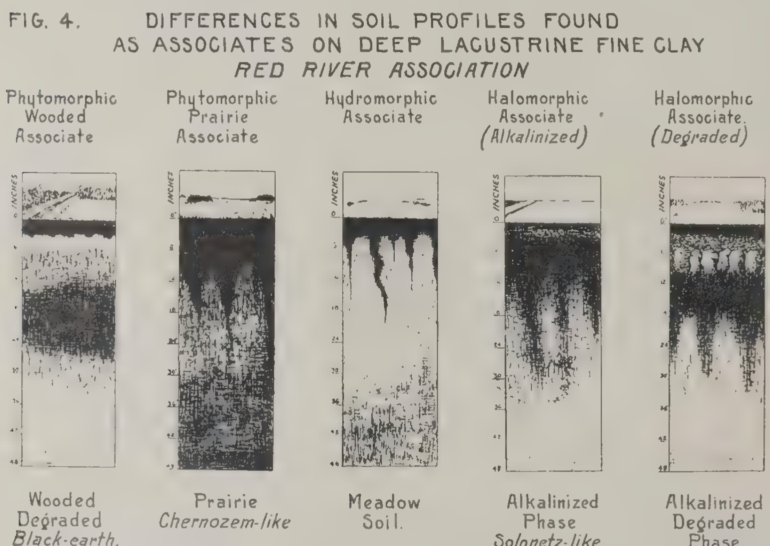


FIGURE 4. Differences in soil profiles found as associates on deep lacustrine fine clay Red River Association.

KEY TO SOILS IN RED RIVER ASSOCIATION

B_1 Soils in association on deep lacustrine fine clays. . . . . . RED RIVER ASSOCIATION—

C_1 Soils developed under well drained or normal moisture conditions. . . . . PHYTOMORPHIC ASSOCIATES

D_1 Well drained prairie.

Soils with very dark brown to black friable A horizon with granular structure, neutral reaction, tongued with icicle-like instrusions into the underlying greyish brown to drab clay. Effervesces with acid immediately below the dark A horizon. . . . . Red River Clay*

*Soil series names for local use are included in the above key.

TABLE 3.—A_1 SOILS OF RED RIVER COMBINATION
LAKE AGASSIZ BASIN

Soils developed on—	Name of association	Associates								Per cent of total area
		C_1 Phytomorphic		C_2 P. H.	C_3 Hydromorphic		C Halomorphic			
		D_1	$D_{1\text{-}3}$	$D_{1\text{-}3}$	D_1	D_2	D_1	D_2	D_3	
		Prairie associate	Wooded associate	Phyto-hydromorphic	Non-salinized phase	Salinized phase	Salinized phase	Alkalinized phase	Degraded phase	
B_1 Deep lacustrine clay	Red River	+	+	+	+	+	+	+	+	66·19
B_2 Delta. silt and lacustrine sediments	Emerson	+	+	+		+				8·22
B_3 Sandy, shallow lacustrine sediments	Altona	+				+				8·27
B_4 Cretaceous clay overwash	Gretna	+				+	+	+		7·73
B_5 Stream outwash and levee	Sperling	+								1·18
B_6 Mixed lacustrine clay and dolomitic outwash	Fort Garry			Complex			Complex	Complex		0·15
B_7 Gravel beach deposits	Agassiz	+								
B_8 River terrace silty deposits	Riverdale	+		+						1·31
Alluvium, and transitional types										6·94+
Per cent of total area		36·94		12·23	29·16		14·72			
Soil types (Groups)		Blackearth (Chernozem-like)	Degraded blackearth	Meadow-Prairie	Meadow	"Solonchak"	Salinized "Solonetz"	"Solonetz-like"	"Solod"	

+ Soil types observed

Oromorphic associates absent.

D_2 Wooded associate (or degraded prairie)
Soil degraded by woodland invasion of prairie. Acid in upper portion of profile, with distinct grey A_2 horizon and tough cloddy darker colored B horizon.................................St. Norbert Clay

D_3 Prairie-woodland transition.
Transition soil between D_1 and D_2 similar to D_2 but without grey A_2 horizon.....................Red River Clay (scrub phase)

C_2 Meadow-prairie soils in transition from meadow to prairie................................PHYTO-HYDROMORPHIC PHASE

D_1 Meadow-prairie phase or immature phase of Red River Clay.
Better drained phase of transition from meadow-prairie. Soils with black A horizon. Tongued into olive drab clay and with lime carbonate concretions...............................McTavish Clay

D_2 Meadow-prairie transition between Red River association and Sperling association.
Similar to D_1 but not so heavy in texture......McTavish Silty Clay (deep phase)

D_3 Poorer drained phase of D_1 but somewhat better drained than Osborne clay.......................McTavish Clay (Low phase)

C_3 Meadow soils developed under locally excessive moisture..............................HYDROMORPHIC ASSOCIATES

D_1 Non-salinized meadow associate. Soils with shallow black A horizon over a grey glei-like clay horizon with more or less profuse iron specks or streaks and concretions. May have thin deposit of muck or peaty material on surface if virgin...Osborne Clay

D_2 Salinized meadow associate.
As D_1 but with gypsum crystals and salting within the soil profile..............................Osborne Clay (Salinized phase)

C_4 Alkalinized Associates........................ HALOMORPHIC ASSOCIATES

D_1 Salinized or shallow phase.
Soil in transition between salinized Osborne clay and Morris clay, with tough black A horizon and feebly developed alkalinized structure over grey clay with profuse carbonate concretions, and gypsum crystals, and more or less salting...........Morris Clay (Salinized phase)

D_2 Alkalinized phase.
Soils with deep black waxy surface. Tough waxy B horizon with prismatic or columnar cloddy structure over grey clay......................Morris Clay

D_3 Degraded phase.
Soils in which the A horizon is becoming gray and more or less ash-like over a B_1 horizon with large columnar clods below which is a tough black tar-like B_2 horizon underlain by a gray clay with carbonate concretions.......................Morris Clay (Degraded phase)

FACTORS RESPONSIBLE FOR SOIL VARIATION

It is evident from the study of the soils of the Red River Valley that the differences in the soil profiles reflect the differential influence of a number of determining factors. The factors here involved may be enumerated as: *(a)* "climate," *(b)* "parent material," *(c)* "native vegetation," *(d)* topographical "position" or "relief," *(e)* the "presence or absence of "ground water" (salinized or non-salinized) and *(f)* "age."

(a) The effect of the regional "climate" is evidenced in the development of black-earth soils in the normal or well drained position under prairie-grassland.

(b) The effect of different "parent material" is apparent in the varietal differences which appear when the soils of any specific type (or group) are compared.

(c) The effect of "native vegetation" is shown in the soil profiles of the prairie associates, the wooded associates and the soils under the influence of woodland invasion of prairie.

(d) The effect of "position" or "relief" and *(e)* the "presence or absence of ground water" is observed in the profiles of the prairie, the meadow-prairie, the meadow, the solonschak and the alkalinized types.

(f) The effect of "age" (or the varying stages of maturity) is noted in the varying phases of alkalinization and degradation, in the transitional soil types, and in the recent alluvial and river deposits. Thus although climate is universally conceded to be the major factor in determining soil type (or soil group) it is apparent that in the Red River Valley Plain, typical zonal or regional soils occupy only a subordinate acreage owing to the extensive tracts of flat topography, imperfect drainage and low relief. These factors have been responsible for the extensive development of local soils types with local "soil climates." Large areas containing a number of different soil types, such as the one discussed, show that the assumption of the extensive occurrence of regional soils from inspection of regional climate data may not be justified; consequently a theoretic regional or climatic soil map may be misleading unless qualified. The occurrence of soil associates showing such wide morphological differences from the typical regional soils emphasizes the importance of giving due weight to the determining factors other than regional climate, both in soil-mapping and in soil-classification.

CONCLUSIONS

1. Typical regional soils occur in the Red River Valley Plain only in the well drained position with smooth topography where the soil climate is in harmony with the regional climate.

2. Associated with the typical regional soils there are a number of other soil types (or groups) differing widely in their morphological characteristics from the typical regional soils. These associated soil types have been determined by the modifying effect of native vegetation, position, drainage or ground water, which together or singly have been responsible for local soil environment, or local soil climate.

3. The soil types (or groups) which occur in this latitude show that varietal differences occur because of differences in texture and mineralogical composition of the parent material.

4. The varying stages of development of these soils indicate the effect of age, or the length of time that the soils have been under the influence of the various determining factors. In other words the degree of development is a function of age.

5. The occurrence of numerous local and intra-zonal soils associated with the regional zonal soil, in the Red River Valley, form an "area complex" which presents a problem in soil classification. However by considering the soils, not only as units, but as associated members that are under differential environment, the "area complex" is simplified and the relationship of the different soils is easily understood.

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Résumé

Types de sols que l'on trouve dans la plaine de la vallée de la Rivière Rouge. J. H. Ellis, Université du Manitoba, Winnipeg, Man.

Dans la plaine de la vallée de la Rivière Rouge, les sols typiques régionaux ne se rencontrent que dans la partie bien drainée, à contours lisses, où le climat du sol est en harmonie avec le climat de la région. A côté de ces sols typiques régionaux et très différents de ces derniers par leurs caractères morphologiques, se trouvent d'autres types ou groupes de sols qui sont le résultat de l'effet modifiant de la végétation indigène, de la situation, de l'égouttement ou de l'eau du sol; ce sont ces facteurs, qui, ensemble ou séparément, sont la cause déterminante des conditions environnantes ou du climat dans lesquels se sont formés ces sols locaux. Les types ou groupes de sols qui se rencontrent dans cette latitude montrent que les différences de variétés proviennent des différences qui existent dans la texture et la composition minéralogique des matériaux de formation. Les phases variables de développement de ces sols indiquent l'effet de l'âge ou la longueur de temps que les sols ont été sous l'influence des divers facteurs de détermination. En d'autres termes, le degré de développement est une fonction d'âge. La présence de nombreux sols locaux et intrazoneaux associés aux sols zoneaux régionaux, dans la vallée de la Rivière Rouge, forme une région complexe qui présente un problème de classification. Cependant, si l'on considère les sols non seulement comme unités, mais comme des membres associés placés dans des conditions environnantes différentes, le problème présenté par la région est simplifié et les rapports qui existent entre les différents sols sont faciles à comprendre.

SOIL STUDIES IN RELATION TO LAND UTILIZATION RESEARCH[1]

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The regional research programme of the Ontario Research Foundation has required the accumulation and correlation of much data regarding existing soil conditions in Ontario. In some regions the results of soil surveys were available, while in others it was necessary to obtain the required information by some speedier and less costly method, so that our experiences may prove of some interest if only as an expression of the viewpoint of the farmer and the land utilization investigator as to the ultimate objective and value of soil surveys.

A survey of agriculture would seem to indicate that the greatest problem confronting agricultural investigators in this country at the present time is that of interpreting research findings in terms of land utilization and crop production. Immediate action is needed to bridge the enormous gap at present existing between scientific progress and actual farm practice, and the solution of this problem is dependent upon just such opportunities as this for workers to view their work in relation to each others' activities and see individual investigations in their true perspective as contributions to a common objective—the most efficient use of our natural resources.

Periods of economic depression invariably create in the public mind a critical attitude toward existing policies of every nature, and it is becoming increasingly evident that this attitude, arising out of the present crisis, holds great possibilities for the future of agriculture in this country. But it is also true that economic stress has exposed, as prosperity never could, the inherent weaknesses in existing methods and machinery for promoting agricultural efficiency, and we are confronted with a demand for more tangible results from the money spent on agricultural education, extension, and research.

During the period of high prices, agriculturists as well as those responsible for appropriations for research, were satisfied with records of unprecedented expansion in cultivated acreage, great increase in total yields, and outstanding achievements of individual scientists in specific branches of research, such as plant breeding, defence against disease and insects, or soil studies. Being convinced of the potential value of such work, they assumed that actual agricultural practice in this country must be a true reflection of contemporary progress in scientific research. But low prices, and the disruption of international markets, have focused attention upon our actual status as agricultural producers, and revealed the startling fact that in reality a huge gap exists between scientific progress and national efficiency in crop production. It would seem that the very wealth of our natural resources and scientific achievements had led us to accept potentialities for accomplishment.

It is impossible in the limited time available to discuss a problem like land utilization research from all angles, and as crop production is the

[1] Presented at the annual meeting of the Soils Group of the C.S.T.A. at Macdonald College, P.Q., June 26 and 27, 1934.

primary factor in our agricultural development. I shall limit my remarks to this phase of land utilization and shall attempt to discuss as comprehensively as possible in the brief time allotted this problem from the following angles:

(1) The present status of agricultural development in this country;

(2) The inherent weaknesses in our present land utilization;

(3) Accumulated experience vs. scientific research as a means of increasing efficiency in land utilization;

(4) The scope of soil surveys in our regional research programme.

PRESENT STATUS OF AGRICULTURAL DEVELOPMENT IN THIS COUNTRY

In order to gauge the value of any type of soil survey in relation to land utilization studies, one must have a very clear conception of the present status of land utilization in individual countries and of the peculiar problems confronting the investigator in these areas.

It is obvious that methods and policies which meet the needs of one country may be entirely inadequate to solve the land utilization problems of another in a different stage of agricultural development. In young countries, for instance, the accumulation of detailed information regarding the productive potentialities of individual areas is the primary consideration and must preceed sound national planning, while in older countries where these capacities have already been determined by generations of experience, more extensive surveys to serve as a basis for national production policies may be the pressing need. Consequently, if we are to obtain a true perspective of our own land utilization problems we must view them in panoramic relationship to agricultural history. It is only against such a background that present problems assume their true significance.

From this viewpoint, agricultural development in Canada is recognized as a logical outgrowth of two economic forces, both of which have demanded the temporary sacrifice of purely agricultural interests to broader national interests. The first of these was the rapid settlement of a new country, and the second was the abnormal European demand for food during and following the Great War. These two forces have been detrimenta to the development of permanently sound land utilization and crop production policies, in so far as they created standards of efficiency which ignored long term considerations.

In a young country lacking transportation facilities, the immediate needs of the pioneer rather than the latent capacity of the land for the production of specific crops, determine land utilization. As transportation and industrial centres develop, however, the demands of individual markets and increased competition influence crop distribution. But it is not until a new country actually becomes engaged in international competition, that a truly efficient use of agricultural resources becomes imperative. Efficiency in agricultural practice is consequently a relative factor. The use of land which represents efficiency to the pioneer, when the creation of a homestead is more profitable than a surplus of unsaleable crops, is inefficient when local markets become acces ible, and even more inefficient in the face of international competition. Similarly, the necessity for intensive cultivation, and conservation of soil fertility, which is the essence

of old world efficiency seems less urgent in a country where labour and fertilizers are expensive, and unlimited areas of fertile land are cheap. Thus throughout the early stages of national development, local standards of efficiency in agricultural practice are continually changing. To prove efficient in the long run, however, agricultural practices must be based on an accurate knowledge of the possibilities and limitations of natural agricultural resources, and it is just this accumulated knowledge which is lacking in a young country such as ours.

Agricultural history offers ample evidence that expansion in production to meet the abnormal needs of war has invariably created standards of efficiency in land utilization and cultural practices which have proved inadequate to meet the increased competition of a post-war economy. True agricultural progress, on the other hand, has developed as an aftermath of periods of unusual stress in the industry. Thus the economic depressions following war, rather than the increased demand during wars, have been the impetus to fundamentally sound progress. During our own early days, when land was free and taxes low, or later when foreign competition was eliminated by war, our national standards of productive efficiency were adequate, but we have now reached the stage in agricultural development where we must recognize the universally accepted standards of efficiency—maximum yields per acre at minimum cost of production. While acreage expansion regardless of these standards may have been a sound policy during settlement and war, it provides little basis for permanent agricultural development.

In view of our agricultural history, it is not surprising that our acre yields should be low in comparison with those of older countries of long established agriculture, but it is surprising that in spite of the progress in agricultural science during the last fifty years our average level of efficiency in production has shown so little change. It is disconcerting to realize that with all the aids of modern science at our command we have been unable to equal the increases in yields achieved by older countries during similar periods before the application of science to crop production problems. Not only have we failed to increase acre yields in most crops to any appreciable extent, but those of ten of our common crops have decreased while costs of production have increased.

THE INHERENT WEAKNESSES IN OUR PRESENT LAND UTILIZATION

Nowhere has the depression been more ruthless in exposing weaknesses in agricultural policies than in regard to land utilization. It has precipitated the necessity for immediate readjustments in production policies, and at the same time disclosed the absence of any planned policy of land utilization which would serve as a basis for sound readjustments, now and in the future. It is evident that haphazard readjustment will be futile as a remedy for haphazard expansion; for curtailment of total yields in some crops, expansion in others and transitions in types of farming, all must be accomplished concurrently with a reduction in production costs to meet world competition.

The agricultural history of older countries shows that flexibility in land utilization has been the most logical and effective defence of the

farmer in the face of economic changes over which he had no control. Indeed, that flexibility in production policies which provides a basis for profitable expansion of individual crops when economic conditions warranted, and a sound, even if less profitable, alternative use of land when economic changes forced readjustments, seems to have been an essential factor in agricultural stability. But at the present time we are faced with the necessity for drastic changes in land utilization policies regardless of the fact that our past experience has provided no basis for such flexibility in agricultural production, or alternative uses of land. As pointed out above, our land utilization still largely reflects the pioneer perspective of efficiency, influenced by the false standards created by abnormal demands and prices of war, and neither of these influences in agricultural expansion encouraged utilization policies which would stand the strain of international competition.

ACCUMULATED EXPERIENCE vs. SCIENTIFIC RESEARCH

The dominant factor in agricultural progress in older countries has been the accumulated experience of operating farmers gained through centuries of trial and error. Their national agrarian policies have made possible a continuity of experiment and observation which disclosed the crop production possibilities and limitations, and the best cultural methods for individual holdings, under a great diversity of economic and social fluctuations. For instance, during the Roman occupation, all available arable land in England was devoted to wheat growing to feed the Roman armies in Gaul. Later the withdrawal of this market caused a reversion to more self-sufficing farming, and a great decrease in cultivated acreage. By the middle of the fourteenth century this mode of farming was again giving way, under the pressure of local competition, to specialization and the distribution of crops according to natural adaptability: wheat north of London, from Suffolk to Gloucester; rye in the North; malting barley in Hampshire, Cambridgeshire, etc. From the Roman occupation to the Great War, England has increased cultivated acreage when war or other economic disturbances have created unusual demand or prices, and subsequently returned millions of acres to grass or rough pasture when economic changes made cultivation less profitable; and it is significant that by the middle of the nineteenth century, before agricultural research as we know it had any appreciable influence on the rank and file of British farmers, this accumulated experience in adapting production of various crops to the fluctuating demands of both local and foreign markets, had developed remarkably efficient and flexible land utilization policies. When scientific findings in genetics, soil conservation, cultural methods, and general agricultural practices became available, they were considered and applied in the light of this accumulated experience, and resulted in an era of unprecedented agricultural progress.

In a young country such as ours, the acquisition of fundamental agricultural knowledge through such accumulated experience has not been possible. We have had neither the length nor continuity of experience which would disclose the most efficient use of our agricultural resources from the purely agricultural standpoint, and yet our growing dependence upon international markets makes it imperative that we establish a sound

basis for flexibility in land utilization and production policies. But even if it were otherwise practical, the accumulation of knowledge necessary for such flexibility, through individual observation and experiment, would be too slow to meet the needs of a country already vulnerable to the economic disturbances of foreign markets. Consequently, we must depend upon science for acquisition of that fundamental knowledge which accumulated experience has provided for older agricultures. But scientific research can provide a successful short-cut to the accumulations of such knowledge only if those in charge of field investigations maintain the perspective of the experimenting farmer, who sees each problem, not as one in chemistry, physics, genetics, or pathology, but as one in efficient utilization of a definite coincidence of agricultural resources. It is this perspective which has been responsible for the ultimate success of the trial and error system in evolving essentially sound agricultural principles throughout the ages, in spite of the great waste of effort and money such repetition of experiment involved.

Scientific research could accomplish in this country in a comparatively few years, that which has taken centuries in the older countries, but only if we recognize the significance of specific and detailed knowledge in agricultural progress. Unless research findings are related to actual growing conditions under which the farmer operates, and are interpreted in terms of practical farm procedure, scientific research cannot replace individual experiment. And in the final analysis the value of land utilization studies in this country must be gauged by their capacity to reduce the necessity for this wastetul repetition of individual experiment.

"Land utilization" as generally used is a misleading term, because what we really mean is utilization of agricultural resources. Land in itself possesses no potentialities for agricultural production apart from the other factors with which it is associated in individual environmental coincidences, neither do individual crops or varieties possess potentialities for yield, quality, or resistance to disease or parasites except in relation to these interrelated factors. Consequently, successful crop production is dependent upon the adaptation of individual plants to a specific coincidence of factors of which soil is only one.

But the limitations of our present academic system demand the artificial subdivision of agricultural science into isolated departments. Limited time and funds force the individual student to specialize and consequently emphasize these divisions. The student who turns to practical farming, immediately proceeds to interpret all his unrelated knowledge into terms of crop production under specific conditions, but the graduate who enters the research field, is often not sufficiently impressed with the fact that such divisions are primarily for academic convenience, and must not be allowed to distort the perspective of the land utilization investigator who must view every problem in crop production as one in the adaptation of plant growth to a specific environmental coincidence, and one which will require for its solution collaboration of specialists in many branches of agricultural science.

The necessity for individual specialization, sometimes obscures the fact that the solution of an isolated problem is not an end in itself, but a potential contribution to the major problems of increasing our efficiency

in the use of agricultural resources. While background and breadth of perspective are chiefly valuable in those responsible for research policies, we must realize that the helper of today is the director of tomorrow, and that breadth of vision will not develop automatically with change of office. The too early specialization of agricultural investigators tends to widen the gap between scientific and practical progress.

THE SCOPE OF REGIONAL RESEARCH

As we have noted above, an outstanding feature of our agricultural development is the failure of farm practice to reflect contemporary progress in the individual branches of agricultural science. This is due chiefly to the following factors:

(1) That habit and tradition have crystallized pioneer practices.

(2) Inadequate provision for that co-ordination and interrelation of isolated findings which are necessary before they are applicable to crop production problems.

(3) That although blanket recommendations are of little value under our great diversity of growing conditions, the individual growth coincidences to which more specific recommendations must be related have not been defined either by fundamental research or accumulated experience.

Consequently, the publication of findings in individual branches of agricultural research, increases, rather than decreases, the necessity for individual farm experiment. To be effective as a means of increasing average production efficiency, scientific findings regarding individual crops must be considered in relation to definite environmental coincidences, while findings regarding light, soil, fertilizers, disease, etc., must in turn be considered in relation to individual crops and varieties in specific environments. Unfortunately, neither the specific coincidences under which growth must proceed throughout this country nor the specific reactions of individual crops and varieties to these growth coincidences have been defined.

It was in an effort to define these growth coincidences which determine our agricultural potentialities, and so provide a basis for effective application of scientific findings to crop production on the individual farm, that the regional research programme of The Ontario Research Foundation was planned. The principles and objectives of this programme have been outlined in a previous publication (*1*). It is essentially an effort to bridge the gap between science and practice, and thus reduce the wasteful repetition of experiment on individual farms. It aims to provide a foundation for sound land utilization policies through co-ordination of many unrelated detailed investigations, and so to combine the speed and accuracy of modern science with the fundamentally sound perspective of the old trial and error system. The possibilities for economy of time and effort inherent in such co-ordinated attack of land utilization problems is evident, but, as noted above, success in operation is dependent upon the ability of investigators to collaborate.

In a country as vast as Canada, with such diversity in type and distribution of agricultural resources dependent for development upon international markets, any provincial research programme must be sufficiently fundamental to form a basis for collaboration with other provinces in the

institution of national production policies. Our present trend towards national marketing must inevitably result in the consideration of production policies from a national standpoint, in spite of the fact that political considerations demand that many agricultural research projects be provincial in scope.

The two systems of agricultural research most commonly employed are subjective and regional. The first confines investigations to specific problems whose solution is of general significance, such as plant breeding or plant pathology. The second confines investigations and relates findings to definite political areas, usually counties in the province of Ontario.

In order, therefore, to interpret individual research findings in terms of actual farm procedure under specific coincidences of crop and environment, it is necessary to correlate these two types of research in a definite plan. For instance, the development of new varieties holds great possibilities, but their successful distribution must be based on a knowledge of their capacity for yield, quality, and resistance to disease under all the environmental coincidences throughout the country, not only the one in which they have been developed.

Owing to the fact that the political units, such as counties, have no agricultural significance, the boundaries of our units for regional research have been determined by ecological conditions, and the findings of subjective investigations are considered in relation to the accurately defined characteristics of those units. Such correlated findings provide a basis for profitable land utilization and crop production in any region. Where comparisons of two regions reveal duplications of growth coincidences, we may assume that results obtained in one would be repeated in the other and thus eliminate repetition and overlapping of research work.

Our regional research studies are an attempt to co-ordinate research, in recognition of the following principles:

(1) That our agricultural progress will be in proportion to our skill in using the agricultural resources at our command;

(2) That these resources consist of definite coincidences of environmental factors which scientific investigation can define;

(3) That individual crops and varieties demand definite coincidences of environmental factors for successful yields at minimum cost;

(4) That correlation of all research in relation to the growth of individual crops in specific environments is the only sound basis for those readjustments in land utilization and farm practices which changing economic and social conditions make necessary.

SOIL SURVEYS

From such a viewpoint, the ultimate value of any type of soil survey must be gauged by its capacity to contribute to the farmer's knowledge of his own crop production possibilities and limitations. It would seem that the greatest weakness in many of our present systems is the perspective which regards a soil survey as an end in itself, and fails to provide for its interrelation with other factors affecting agricultural use. The fallacy of assuming that soil types, or subtypes, in themselves possess consistent potentialities for crop production or other agricultural use, apart from

the environmental coincidence with which they are associated in different agricultural areas, cannot be too strongly emphasized. Findings regarding individual soil types must be correlated with a knowledge of other factors such as topography, temperature, moisture, and light before such findings possess any value as indicators of crop production possibilities. For instance, a soil type which is extremely valuable for peach production when associated with the climatic conditions of the Niagara Peninsula below the escarpment may be almost worthless when situated on top of the escarpment a mile distant where peach trees will survive, but because of slight deficiencies in temperature will not bear consistently. Variations within one soil type, even so slight as a few degrees difference in soil temperature at root depth, may greatly change its value for production of a single crop, while differences in the agricultural history of adjoining fields may result in great diversities in physical and chemical characteristics and in productive possibilities.

In settled agricultural areas, experience and tradition prevent gross misuse of soil types. In the Niagara Peninsula, for instance, experience has proved the superiorities of certain soil types for peach or cherry orchards as well as the most profitable use for the heavy soils in this climate, and crops are generally distributed on this basis. But the enormous diversities in yields of various crops on a single soil type throughout a region where other factors are remarkably uniform, indicate that minor variations in depth of soil, soil temperature, topography, etc., within single soil types are as potent as distinct differences in type in affecting productivity of individual crops. That lack of definite knowledge regarding the distribution of these variations and their effect upon plant growth has been responsible for much misuse of land. Recent investigations have shown that not only poor yields of peaches and short-lived orchards, but heavy losses from specific diseases, have been consistently associated with minor variations in a single soil type thought to be normally optimum for peach growing.

Soil specialists are agreed that one of the major difficulties confronting those planning soil surveys is to decide upon the amount of detail which should be included. If surveys are to be dependable as a basis for land utilization, even the slightest variations in soil types cannot be overlooked. It is obvious that any attempt to map accurately the distribution of all variations in types and sub-types of soil in farming areas of such diversity as ours would be impractical at the present time. Neither is there any uniformity in the chemical or physical characteristics of a single type, even within one region. And yet it is just such specific information which is required by the farmer if science is to replace trial and error on the individual farm.

It is extremely valuable for statistical purposes and national planning to know the approximate extent and distribution of various soil types, but such general and unrelated information is of little value to the farmer confronted with an actual problem in land utilization. Therefore, the value of available soil maps, in relation to immediate land utilization studies in most areas, must be general rather than specific. For instance, when all types and sub-types in a region have been isolated by a soil survey, and each of these considered in relation to the major environmental factors, it is a

relatively simple matter to offer general recommendations as to the most profitable uses and methods of culture for definite variations within this area. But under our present system of soil mapping, success in applying these general findings is still dependent upon the ability of the farmer to identify slight variations in his own soil types, and upon individual experiment to determine the presence and effects of variations in physical and chemical characteristics. Consequently, we concluded that from the standpoint of determining crop production potentialities on individual farms, the chief value of existing soil surveys lay in the isolation and identification of the various types and sub-types present in any region. But we also discovered that these essential data could be secured in a fraction of the time by other methods and thus obviate the necessity for delay in those regions where soil surveys had not been completed. Comparisons of records showed that a study of numerous crosscuts of a region isolated all the types and sub-types revealed by the more detailed survey, and in a fraction of the time, although it did not determine the extent or distribution of each. It is not the desire to discredit detailed soil surveys—such information is essential for institution of general policies, and national planning but in our immediate objective of providing the individual farmer with accurate knowledge of his own conditions it has little, if any, advantage over speedier and less costly systems. Moreover, the necessity for immediate readjustments in use of land in this country makes it impossible to delay this phase of land utilization work until complete detailed soil surveys of all regions are available.

Having found soil maps impractical as a means of delineating the variations of soil types on individual farms, it seemed that the most logical alternative was to assist the farmer in identification of his own types, and to provide him with definite information as to the best use of each under his own conditions. Consequently, soil profiles of all types are being

FIGURE 1.—A group of soil profiles used to illustrate soil types to farmers.

prepared, and are on exhibition accompanied by paintings showing natural coloring before exposure. All general findings applicable to the entire region, regardless of soils, are filed as regional, while the data applicable to a specific soil type wherever found in the region are filed in relation to that definite coincidence of factors.

Investigations to determine the optimul conditions for productivity of individual crops and varieties, and the reaction of plants, cultivated and wild, to the various coincidences of factors present in each region, are carried on concurrently with the more general regional work. Consideration of all findings in their interrelation indicates the most profitable present use of land and also provides a basis for alternative uses should need arise. It has been the practice in many soil surveys to label certain agricultural areas as marginal or submarginal and advocate their abandonment or reforestation. There have undoubtedly been mistakes in land settlement all through this country, and it is only reasonable that every effort should be made to isolate less productive areas and to settle the best agricultural land first. Nevertheless, in all land utilization studies it is essential to recognize the fact that some lands judged sub-marginal by one generation of farmers have proved highly profitable in another under different economic conditions and improved agricultural methods. For this reason it is important that no partiality be shown in thoroughness of regional investigations and that detailed information of all areas should be on file as a basis for future readjustments.

The proposed soil survey according to genetic types will be a valuable source of data when complete. But great economy in agricultural research could be effected if greater co-ordination were maintained between soil surveys and other relevant researches. For instance, if all regional investigations in meteorology, ecology, agronomy, pathology, entomology, etc., could be carried on simultaneously with soil surveys, much repetition of research to determine the effects of soil variations upon plant growth and crop production in individual areas could be avoided.

By recording all findings in relation to specific coincidences of environmental factors which have been accurately defined, we are building up a permanent structure of correlated fundamental information which will serve as a basis for application of all relevant research findings of the future, and thus reduce the necessity for individual experiment.

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ABSTRACTS

SOIL SURVEY BY PLANT ANALYSIS. Andrew Dingwall, Research Spectroscopist, Columbia University, New York City.[1]

In the past soil survey has been confined to two types of work viz.:—field soil classification and chemical analysis to determine the chemical contents of the soil. It was suggested that a new type of survey be made based on the analysis of plants grown on the soil under investigation. Samples of soils and plants grown in the province of Quebec were submitted to spectrographic analysis and the spectrograms projected and discussed before the meeting. It was shown, for example, that there was no correlation between the quantity of chromium present in the soil and the quantity in the plant. Other elements such as molybdenum, manganese, iron, copper, strontium, barium, lithium, rubidium, and so forth, were discussed.

It was further pointed out that in the future soil surveys must take into consideration the nature and the quantity of elements found in the plant with regard to their possible influence on public health. As an example, it was shown that in certain localities the plants were relatively rich in lead and it was suggested that the ingestion by humans or livestock of large quantities of leafy plants grown there might become a health hazard. The finding of molybdenum in certain muck soils raised the question of the effect of molybdenum on the animal economy.

[1]This paper, read at the June, 1934, meeting of the Soils Group, C.S.T.A., was published in part in the Canadian Journal of Research *11* : 32-39, July, 1934, "Studies on the Distribution of Molybdenum in Biological Material: 1. A Spectrographic Study of the Occurrence of Molybdenum in Plants Grown in the Province of Quebec," by Andrew Dingwall, R. R. McKibbin and H. T. Beans.

ORGANIC MATTER AND ACIDITY IN PODSOL SOILS. H. J. Atkinson, Macdonald College, Quebec.[1]

Leached with distilled water, the raw humus of the A_1 horizon of Quebec virgin podsols gave percolates of gradually increasing pH values over periods of 14 weeks, beginning in two instances at 4.3 and rising to 5.4, and in a third at 3.8, rising to 4.8. When concentrated by evaporation to one tenth or one twentieth of the original volume the percolates retained 83.5 to 99% of their total acidity. The concentrates were fractionated by dialysis through cellophane. From 46 to 91% of the acidity dialyzed. In five soils, 47.5 to 56.4% of whose acidity dialyzed, total sulphuric acid amounting to 30 to 52% of the total acidity, was found in the dialyzate. The free (alcohol-soluble) sulphuric acid amounted to 9.5 to 23% of the total acidity of the percolate. Phosphoric acid was present in mere traces in some samples but in one instance the total phosphoric acid content was sufficient to account for 28% of the total acidity, if it is present in the free state.

[1]This paper, read at the C.S.T.A. Soils Group meeting at Macdonald College, June 1934, was published as follows: Chemical Studies on Appalachian Upland Podsol Soils, II. Organic Matter—Acidity Relations. H. J. Atkinson and R. R. McKibbin. Can. Jour. Res. *11* : 759-769. December, 1934.

THE RATIO METHOD OF COUNTING SOIL BACTERIA. P. H. H. Gray, Macdonald College, Quebec.[1]

This paper was descriptive of a method developed at Rothamsted for determining the number of bacteria in soil by means of stained films, in which a known number of microscopic particles of indigo have been dispersed.

Tables were presented showing that the method can be relied upon to give close agreement between different workers and parallel samples of soil. The numbers of bacteria (to be precise, cells identified as bacteria, with the reservation that some of them may be those of actinomyces) in certain soils were also shown in a table, in which the ratio of the total cell count to the plate count was also presented. By means of diagrams it was shown that bacterial numbers may be correlated with crop yield, and that significant differences in numbers in a single plot of field soil may occur within a few hours.

[1]This paper, read in June, 1934, at the C.S.T.A. Soils Group meeting, was published in full in the Proceedings of the Royal Society of London, Series B, No. 795, vol. 115, pp. 522-543, August, 1934. "The Numbers of Bacterial Cells in Field Soils, as Estimated by the Ratio Method," by H. G. Thornton and P. H. H. Gray, with appendix by R. A. Fisher.

L'UTILITE DE LA CARTE AGRONOMIQUE[1]

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Il serait certainement téméraire de dire que l'étude du sol en relation avec la plante est aussi ancienne que les autres sciences. Le sol était sans doute trop près de l'homme pour que celui-ci fût porté à s'en occuper.— Il n'est pas nécessaire pour constater ce fait de remonter aux temps anciens où la richesse ne consistait pas tant en biens fonds qu'en nombreux troupeaux. Même au commencement du vingtième siècle le sol intéressait si peu les scientistes qu'on le considérait encore comme une branche de la géologie. En effet, il y a à peine une trentaine d'années, on considérait le sol comme du roc réduit en poussière plus ou moins fine, à la surface de laquelle, s'était accumulée une certaine quantité de matière organique. On croyait qu'un sol formé de roches calcaires était toujours riche en chaux, qu'un autre formé de roches pauvres en acide phosphorique devait nécessairement être pauvre en cet élément. Avec le concept que l'on avait des sols, il suffisait donc de connaître les roches qui leur avaient donné naissance, pour être fixé sur les propriétés de ceux-ci.

Mais voici que vers 1914 les pédologistes russes firent connaître au monde scientifique les résultats de leurs travaux de recherche sur les sols. C'est alors que l'on vit que le facteur principal était le climat qui placait la roche effritée dans certaines conditions de température, de végétation, de précipitation, etc., lui apportant des caractéristiques totalement différentes. C'est ainsi qu'un sol granitique, formé dans la province de Québec, ne ressemble pas à un autre sol de même origine, mais formé au pôle nord ou dans les provinces des Prairies.

Si le sol est le produit des conditions environnantes, on ne peut donc guère acquérir de connaissances précises à son sujet qu'en l'étudiant dans son milieu. C'est ce en quoi consiste le travail de classification des sols et de la carte agronomique.

Cette étude du sol sur place est certainement un travail long et dispendieux. Les avantages que l'on est en droit d'attendre sont-ils suffisants, pour justifier un tel travail? C'est ce que nous nous proposons de démontrer en indiquant les services que ce travail pourrait rendre aux particuliers comme au peuple canadien.

I

Les données fournies par le rapport de la classification des sols, dit Milton Whitney (3) sont la base fondamentale de l'organisation des systèmes de culture d'une ferme; les générations présentes et futures doivent en bénéficier.

Qu'un cultivateur change de région ou qu'un citadin veuille s'établir sur une terre, ils verront dans ce rapport une aide précieuse (15) qui les empêchera d'être induits en erreur par les personnes qui sont intéressées à les voir se diriger dans telle région particulière. Veulent-ils se choisir

[1] Travail présenté à la réunion annuelle du Groupe des sols de la C.S.T.A. tenue au Collège Macdonald, P.Q., les 26 et 27 juin 1934.

une région avec l'intention d'y pratiquer une certaine culture, ils verront par le rapport si la partie de terre convoitée répond bien à leur désir. Celui-ci leur dira que dans tel endroit, c'est telle culture qui est la mieux adaptée, ou tel mode d'exploitation qui est en honneur.

Supposons que l'on veuille diriger un groupe de colons sur une région particulière: si l'on avait une classification des sols, on pourrait leur donner des renseignements précis sur la valeur du district, ses possibilités agricoles, l'éloignement des centres importants, les facilités de communication, etc. Ils auraient une idée assez juste de la région qu'ils convoitent, même sans l'avoir visitée.

Le cultivateur émigrant n'est pas le seul à retirer des bénéfices de la classification des sols, celui qui reste attaché à la succession de ses aieux y trouvera également de précieux avantages.

Voici qu'un bon jour ce cultivateur s'aperçoit qu'avec les méthodes de culture de son arrière-grand-père, il ne peut réussir à joindre les deux bouts. Que faire s'il ne veut pas être obligé de vendre sa terre? Adopter un meilleur système de culture? Mais quel sera ce système? S'il n'y a pas de classification des sols dans la région, l'agronome pourra bien lui donner de sages conseils, mais sa besogne sera bien simplifiée s'il a entre les mains la carte agronomique de la région. Avec cette carte, il pourra situer la ferme en question et voir les types de sols qui la composent. Le rapport lui dira ensuite le point faible de cette ferme: manque d'éléments de fertilité, mauvaises conditions physiques, mauvaise adaptation des plantes aux sols, mauvaises cultures pour les exigences du marché, etc. En touchant du doigt le point faible, il sera plus facile d'y remédier; c'est ce que l'on a fait en maints endroits de la Saskatchewan (11) et les résultats sont très probants.

Il pourra comparer le sol de sa ferme avec celui d'autres régions plus prospères, situées sur un sol d'un même type; il verra s'il y a lieu de changer son système dù culture ou d'adapter certaines cultures spéciales. En effet, avec le rapport, dit J. A. Bonsteel (14), l'horizon d'observation du cultivateur se trouve beaucoup élargi et il peut bénéficier de l'expérience des cultivateurs d'autres régions.

La rive est de la Baie Chesapeake, dans le Maryland et le Delaware, est une région ou la culture du blé et du blé-d'Inde ne réussissait pas. Les cultivateurs étaient pauvres et tout annonçait la misère. Les études faites après la classification des sols montrèrent que cette région serait bien adaptée pour la culture des petits fruits. L'introduction de ces récoltes révolutionna complètement la région et aujourd'hui nous y trouvons des cultivateurs prospères (12).

La même chose peut se constater dans le comté de Norfolk en Ontario, avec la culture du tabac.

II

Ces services rendus aux cultivateurs par la classification des sols méritent sûrement d'être considérés, mais les avantages de la classification des sols sont plutôt d'ordre général.

Pour mieux apprécier ces avantages généraux, nous jetterons un coup d'œil sur l'utilité de la classification au point de vue national, au point de vue colonisation et au point de vue agricole.

FIGURE 1. C'est le manque de classification qui a fait défricher des terres aussi rocailleuses que celle-ci. L'epierrement demande plus de travail que le défrichement. C'est une terre sablonneuse, plutôt pauvre

Lack of an adequate soil survey permits the clearing of rocky land, such as shown. This clearing requires much labour and leaves the settler with poor gravel soil.

FIGURE 2. Colonie nouvellement ouverte par la Société de Colonisation de Québec: Ste-Anne de Roquemaure, Abitibi. A noter l'absence complète de roches; c'est une belle terre argileuse.

New colony established by the Colonization Society of Quebec; Ste. Anne de Roquemaure, Abitibi. Note the complete absence of stones; this is a good clay soil.

Le rapport de la classification des sols, en nous donnant un aperçu si détaillé sur les conditions du sol, n'est autre chose qu'un inventaire détaillé des ressources du pays. Il localise les cours d'eau, les chemins de fer, les routes, etc. Il peut venir en aide aux ingénieurs, pour l'établissement de nouvelles routes, car il indique la topographie du terrain, l'éloignement des autres chemins publics et l'emplacement de la matière première pouvant servir à la construction de ces routes, comme le gravier, le sable, etc., etc.

Une connaissance précise des sols peut être très précieuse pour la construction de nouvelles routes ou l'amélioration des anciennes. Un classificateur expérimenté, qui connait bien le sol dans ses conditions naturelles, dit W. I. Watkins (7), peut facilement trouver les causes de la détérioration de certaines routes au printemps et y trouver des remèdes.

Le rapport nous donne aussi une idée de la condition sociale des habitants, de leur richesse et de leur instruction, car il nous dit assez bien ce que valent les terres et les troupeaux, et la carte agronomique nous montre les sites des écoles, des églises ou d'autres bâtisses d'utilité publique. En un mot, comme le dit C. B. Williams (2), la classification des sols sert comme référence générale.

L'industrie pourrait également retirer de précieux avantages de cette classification, car elle donne une description détaillée et exempte de préjugés des ressources (15) d'une région. Les entreprises industrielles qui dépendent directement du sol (16), pour obtenir leurs matériaux bruts, comme la glaise, la pierre à chaux, la marne, etc., y trouveraient de précieux renseignements pour la réussite de leurs affaires.

Les banques et les compagnies de prêts agricoles trouveraient également de précieuses indications dans le rapport de classification, pour déterminer la valeur des terres et pour consentir des prêts aux cultivateurs. Comme le fait remarquer Charles H. Seaton (15), les compagnies de prêts trouvent dans ce rapport des renseignements précieux quand elles veulent consentir des avances sur certains sols de telle région.

Aux Etats-Unis, les compagnies d'assurance (3) se servent de la carte agronomique, pour déterminer l'état sanitaire d'une contrée, car, dit R. Harcourt (3), la santé et le bien-être d'un peuple sont en relation intime avec le sol: sur tel sol en trouvera tel degré de confort et progrès.

La classification des sols rend encore de précieux services dans l'établissement du rôle d'évaluation, pour le paiement des taxes. En effet, le rapport indique clairement la valeur des différents sols d'une même paroisse; il ne reste plus aux évaluateurs qu'à déterminer la valeur des bâtisses.

Le professeur Hansen (11) trouve que ce système promet de donner de très bons résultats pour la taxation des terres de la Saskatchewan.

Un autre point de vue qui n'est pas à négliger, c'est le point de vue colonisation. En effet, la classification des sols nous donne une idée précise de la valeur du sol et de son développement possible dans l'avenir. Il est nécessaire, dit Hugh H. Bennett (2), pour notre bien-être et celui des enfants de nos enfants, de ne pas défricher des terres qui conviendraient davantage à la forêt. Il a été commis bien des erreurs dans ce domaine: certaines terres ont pu produire pendant quelque temps, sous la poussée

des cendres du défrichement, mais maintenant elles sont presqu'incultes, et par conséquent représentent une perte pour le domaine forestier et agricole.

Avant de pousser des colons dans une région, ou les laisser s'y implanter, il faudrait voir à ce que le sol puisse les faire vivre, sans qu'ils soient obligés de recourir à d'autres ressources pour pouvoir obtenir leur subsistance. C'est le rapport de classification des sols qui dira si les sols que l'on destine à la colonisation pourront faire vivre leur propriétaire une fois le bois parti (8). Plusieurs fermes du Michigan ont été abandonnées (2) durant les années qui ont précédé la crise actuelle; la classification de ces sols a montré que toutes ces fermes appartenaient à des sols classés, comme improductifs ou peu productifs.

Il est très important de connaître la productivité des différents sols d'une région; mais il est encore plus intéressant de connaître la superficie de chacun d'eux. Ceci est surtout important lorsqu'il s'agit d'ouvrir une nouvelle région à la colonisation. Il peut arriver qu'en un endroit donné, il y ait des terres très fertiles, mais en quantité restreinte, et entourées d'autres terres pratiquement incultes. Devrait-on les défricher? Certes non, car les quelques propriétaires de ces sols fertiles pourront bien avoir de belles récoltes, mais dans quelle situation sociale se trouveront-ils? Entourés de forêts ou de malheureux colons qui ont vu s'écrouler avec chaque arbre une parcelle de leur espoir déçu.

S'agit-il de fonder une nouvelle région, la classification servira de guide pour choisir les meilleures terres d'abord, pour prendre ensuite les moins bonnes, lorsque les conditions se seront améliorées. De même le colon en ayant une idée exacte du fond de la terre, pourra choisir une région où le sol conviendra le mieux à ses aspirations futures.

En plus de ces facteurs, qui regardent directement le sol, la classification peut donner d'autres indications qui affecteront grandement la valeur des terres. Ainsi elle montrera les voies de communication par terre ou par eau, les marchés et les conditions de la région; elle nous donnera aussi une idée du climat, de la topographie, de la population et des industries locales.

Toutes ces indications contribueront à améliorer cet état de choses que déplorait I. D. Rice (2): "Ceux de nous qui ont travaillé à la classification des sols ont pu voir les luttes pénibles de bien des pionniers, qui ont dépensé les plus belles années de leur vie sur un sol improductif, tandis qu'il y avait tout près d'eux des sols fertiles sur lesquels ils auraient pu tout aussi bien s'établir.

Nous avons vu les principaux avantages que l'on peut retirer de la classification des sols au point de vue national et colonisation; les services qu'elle pourrait rendre dans le domaine agricole ne sont certainement pas moindres. La classification, dit le professeur R. Harcourt (3), constitue un inventaire complet des sols; elle a la même raison d'être en ce qui concerne les ressources du sol que l'enquête géologique en ce qui concerne nos ressources minérales. En effet, la classification des sols nous donne un rapport détaillé des différents sols; entre autres renseignements, elle nous donne une idée précise des différentes propriétés de chaque sol.

La productivité d'un sol est en relation très intime avec ses propriétés physiques et chimiques. Qu'est-ce que nous dit la classification des sols

à ce sujet? Par l'analyse mécanique, mentionnée dans le rapport, nous connaissons la grosseur des particules; nous voyons si nous avons affaire à un sol sablonneux ou argileux. Ceci est très important, puisque le sol sablonneux, en contenant la même quantité d'éléments nutritifs, sera toujours moins productif que le sol argileux.

L'égouttement, qui a une si grande importance sur la productivité d'un sol, est encore très bien indiqué dans le rapport.

La topographie joue aussi un certain rôle sur la valeur d'une terre; un sol très accidenté sera plus lavé par les eaux et par conséquent les éléments nutritifs les plus solubles auront une tendance à s'épuiser plus rapidement. Dans certains cas, les accidents de terrain pourront empêcher la culture d'une terre qui par ailleurs serait très productive. La topographie du terrain est encore très bien indiquée dans le rapport de la classification des sols.

Le rapport indique encore la composition chimique du sol. Cette analyse ne donne pas beaucoup d'indications sur le pourcentage des éléments fertilisants utilisables, mais quand elle est complétée par l'étude de la végétation et l'analyse mécanique, elle a certainement beaucoup plus de valeur.

Si l'on rapproche ensuite ces résultats des données que l'on a par ailleurs sur les procédés de formation du sol et sur la nature des éléments qui ont servi à le constituer, on est assez bien en mesure d'en connaître exactement la valeur productive.

Une fois que l'on connaît d'une façon aussi précise ces différentes propriétés, il est beaucoup plus facile de faire des expériences qui pourront être valables pour tous les sols du même type. La grande valeur du rapport, dit R. Harcourt (3), repose dans ce fait qu'il forme la base des études pratiques et systématiques des problèmes du sol.

Si l'on pouvait baser sur le rapport de classification des sols toutes les expériences que l'on poursuit en agriculture, tant dans l'Ouest que dans l'Est, on serait en mesure de tirer de bien meilleures conclusions de ces expériences. On saurait que les résultats de certaines expériences s'appliquent très bien sur telle ferme, mais s'appliquent moins bien sur telle autre, parce que son sol n'est pas le même que celui où s'est poursuivie l'expérience.

On pourrait encore se baser sur ce rapport pour l'établissement des stations expérimentales ou des champs de démonstration. Cela permettrait de varier l'importance des stations avec l'importance des types de sols, sur lesquels elles sont situées. Chaque région aurait sa station de première importance, située sur le type de sol le plus important, avec des sous-stations situées sur les types de sols les moins importants. Les résultats que l'on obtiendrait des expériences faites dans ces conditions permettraient de donner des conseils beaucoup plus précis aux cultivateurs de telle ou telle région en particulier.

Quelques résultats des expériences conduites dans divers états américains suffiront pour prouver cet avancé. J. Wilder, dans un manuscrit inédit "The Apple Soils of New-York" constate que certains sols, dans le même district de New-York, portent des pommiers donnant une "Rhode Island Greening" verte, tandis que d'autres produisent une "Rhode Island

Greening" jaune. Il a trouvé également que le meilleur sol pour la Greening n'est pas celui qui convient le mieux pour la Baldwin ou d'autres variétés.

Des expériences semblables ont été faites à l'université d'Illinois (2) On a établi des champs d'expériences sur différents types de sol, sur lesquels on pratiquait divers systèmes de rotation, avec les plantes usuelles de la région. Certains types montraient leur défectuosité dans la production, soit de l'avoine, soit du soja, tandis que d'autres se révélaient très bons producteurs de maïs, d'avoine, etc.

Ces expériences nous montrent donc que chaque type de sols montre des préférences marquées pour telle ou telle plante en particulier. En effet, la classification des sols, dit L. F. Gieseker (17) nous a rendu de grands services en montrant l'adaptation de certaines aires pour la production de certaines récoltes et en empêchant la répétition des désastres qui se sont produits sur certaines terres pauvres.

C'est cette classification qui a rendu possible en Illinois la fondation d'écoles de fertilité du sol. Les cultivateurs sont réunis en différents endroits, où des experts discutent avec eux leur système de culture, l'avantage qu'ils auraient à adapter tel ou tel autre, la quantité et la qualité d'engrais à employer, etc. Cette méthode d'enseignement, dit E. E. DeTurk (2) a réussi à réveiller même les plus endormis. C'est là qu'on leur indique que, si les fertilisants ne donnent pas les résultats qu'ils devraient donner, c'est à cause d'une mauvaise connaissance du sol (5).

Une connaissance si exacte de nos sols et les données expérimentales sur l'adaptation des plantes aux sols, serait également très utile, pour l'étude des sols dans les différentes institutions agricoles du pays. L'étude des sols serait certainement rendue plus intéressante si l'on pouvait dire que dans telle province il y a tel sol possédant des propriétés particulières que les podsols, si nombreux dans Québec, font place aux tschernosems dans telle ou telle province de l'Ouest.

Pour résumer, nous pourrions dire avec le Professeur Hansen, de Saskatchewan (11): La classification de sols est une chose fondamentale. Pourquoi le cultivateur n'en connaîtrait-il pas aussi long sur son sol qu'il en connaît sur les animaux et la mécanique? Si le développement et la prospérité d'une région dépendent du sol pourquoi ne pas chercher à connaître ce sol à fond; ou encore avec R. S. Smith (16) que la classification des sols fournit une richesse de renseignements qui permettent l'utilisation adéquate des terres.

Résumé et conclusion

Nous voyons donc que la carte agronomique peut rendre de réels services aux cultivateurs canadiens. Elle les guide dans le choix des régions; elle leur dit avec exactitude, sans parti pris, la valeur du sol convoité et les cultures qu'on y pratique. Elle éclaire également le cultivateur qui veut améliorer sur sa ferme son système de culture et lui permet de profiter de l'expérience des cultivateurs, ayant des sols semblables, mais situés dans des régions différentes.

Comme la classification des sols est un travail de grande envergure, elle profitera surtout à la nation. C'est pourquoi nous avons montré

que la classification sera surtout avantageuse, au point de vue national, en faisant l'inventaire complet d'un pays, au point de vue colonisation, en concentrant l'effort des colons, sur des terres qui sont réellement propres à la culture, et au point de vue agricole, en permettant une adaptation plus adéquate de la plante aux différents types de sols.

Ces avantages au point de vue théorique trouvent leur application dans la pratique. Qu'il nous suffise, pour appuyer cet avancé, de rappeler l'enquête que faisait le Dr. Auguste Pépin, en novembre 1921. Il envoya aux agronomes de l'état de New-York, une lettre circulaire leur demandant ce qu'ils pensaient de la carte agronomique. Les réponses qu'il a reçues sont presque unanimes à vanter les bénéfices que l'on peut retirer de ce travail.

Est-ce que ce travail est assez avancé au Canada, pour que l'on puisse espérer en retirer tout le bénéfice que nous venons de mentionner? Il serait difficile de répondre dans l'affirmative, du moins pour Québec, les Maritimes et certaines provinces de l'Ouest.

Mais permettez-moi de formuler, en terminant, un vœu: que la Groupe des Sols de la C.S.T.A., organisé par le professeur Joel, secondé par le professeur Ellis, son digne continuateur, parachève aussi rapidement que possible, la carte agronomique commencée l'an dernier.

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Summary

THE VALUE OF THE SOIL SURVEY. Auguste Scott, Agricultural College, Ste. Anne de la Pocatière, P.Q.

An endeavour has been made to show that an agricultural map would be of great benefit to the Canadian farmers by guiding them in the choice of a locality and supplying them with disinterested and exact information as to the value of the soil and the crops that may be grown there. It would also enlighten those who desire to improve their cropping systems, and enable them to benefit by the experience of other farmers having soils of the same type, in other parts of the country. Soil classification has such a wide scope that the whole nation would benefit by it. From a national point of view it would be very beneficial by supplying a complete inventory of the country; as regards settlement, by concentrating the settlers' efforts on land which is really fit for cropping; and as regards agriculture, by providing for a better adaptation of the crops to the various types of soils. These advantages would also have a practical application. To support this claim, I need only recall the investigation conducted by Dr. Auguste Pépin, in November, 1921, when he asked the New York State agronomists, by circular letter, what they thought of soil survey. The answers which he received were almost unanimous in praising the advantages of this work.

Is this work sufficiently advanced in our country, to produce all the advantages which we have claimed for it? This can hardly be answered in the affirmative, at least in so far as Quebec, the Maritimes and certain Western provinces are concerned. In conclusion, may I express the hope that the Soils Group of the C.S.T.A., shall bring to completion, as soon as possible the agricultural map on which work was started last year.

A STATEMENT ON THE REPORT OF RESEARCH AND EXPERIMENTAL PROJECTS IN SOILS UNDER WAY IN CANADA[1]

This report, as compiled to June 1, 1934, lists over 100 separate projects which have been officially reported as being under way in Canada at the present time. The number of projects alone does not convey a true conception of the nature and amount of the work being done on soil problems. Because of the broad scope of research and experimental work in the investigation of soil problems ranging from fundamental studies of the soil itself through the whole field of soil-plant relationships in crop production, it is obviously difficult to make more than a very broad classification of these projects at this time. To indicate something of the field of investigation covered in the projects reported, they may be grouped roughly, as follows:

Soil Survey—10 projects

Soil Chemistry—16 projects

Soil Fertility—Field experiments and correlated laboratory investigations—49 projects

Soil Cultivation—5 projects

Soil Microbiology—5 projects.

In analyzing the information contained in the project outlines, only a general statement concerning the nature and scope of the work in each of the above fields, is possible at this time.

Soil Survey, Soil Classification and Soil Mapping are reported as being conducted as definite projects in British Columbia, Saskatchewan, Manitoba and Ontario, the type of survey (reconnaissance or detailed), field procedure, the scheme of classification, etc., varying according to the requirements of each Province. Soil Surveys in connection with other investigations are also being carried on in Alberta and Quebec. New Brunswick, Nova Scotia and Prince Edward Island have not been reported as having definite soil survey or soil mapping projects under way.

The survey projects under way in some cases, involve correlative laboratory studies of the soil types in relation to both soil formation and fertility problems.

The projects classified under soil chemistry include extensive investigations on the nature of phosphorus and potassium compounds in soils; solubility studies of phosphorus and potassium compounds; vertical distribution of the readily soluble phosphorus and potassium in the profiles in relation to soil type; studies on fixation of phosphorus and potassium; nitrate production in soils under different treatment; reaction in relation to soil type; investigation of extraction and analytical procedures with soils, etc. Most of this work is fundamental in nature and the principles

[1] A preliminary statement on the work of the Soils Group of the C.S.T A. in compiling a Report of Research and Experimental Projects in Soils Under Way in Canada. This report has been completed and will be available for distribution in mimeograph form in April, 1935. The preliminary statement was prepared by Prof. G. N. Ruhnke, Ontario Agricultural College, Guelph, and presented to the Soils Group of the C.S.T.A. at the annual meeting at Macdonald College, June, 1934.

established are being applied to the study of problems of soil classification, plant nutrition and fertilization.

As the report shows, the largest number of projects falls into the group designated as soil fertility projects. In practically all of the Provinces, this phase of soil work is receiving most attention. Field plot experiments with a great variety of crops, single and combination fertilizer treatments, rotations, methods of application and rates of application of commercial fertilizers and manure, and greenhouse pot experiments are being carried out in connection with fertility problems. The most extensive work on field experiments is reported by the Field Husbandry Division of the Central Experimental Farm, although some provincial institutions have very extensive programmes of field fertility investigations.

Several of these projects involve physical, chemical and bacteriological laboratory investigations. No doubt the urgent demand for information relating to the most effective use of commercial fertilizers in crop production has resulted in the great emphasis placed on this phase of soil work.

Projects on methods of cultivation are also reported by the Field Husbandry Division of the Central Experimental Farm, Ottawa. In the case of the various provinces, projects of this type have not been organized to any great extent.

Projects in soil micro-biology are reported from British Columbia, Manitoba, Alberta and Quebec. Some of this work is strictly fundamental in character and some of it is being done in connection with other research and experimental projects in soil fertility. The reports received would indicate that this phase of soil investigation has not received extensive attention generally throughout the provinces.

The present status of soil work in Canada, as gleaned from the reports of projects sent in from the various provinces and from the Central Experimental Farm at Ottawa may be briefly summarized as follows. By far the largest number of research and experimental projects with soils fall in the field of soil fertility investigations. In practically all provinces, this phase of the work has received, and is continuing to receive, most emphasis and attention. Projects in soil chemistry are next in order of number of projects, whether in fundamental studies or in connection with soil survey and soil fertility investigations. Soil survey projects are next in order of number and are extensively developed in a number of the provinces. In some provinces, no soil survey work has been reported as being under way.

Actually, a very large amount of work in soil investigation is being done at the present time, although the amount of laboratory investigation of a fundamental nature is much less than the amount of work being done in a field experimental way. There is a trend toward the development of more extensive fundamental laboratory investigations which are desirable if the most successful experimental work is to be carried out in the field and applied through the extension service. It would appear that there is opportunity for considerable development in the field of fundamental investigations in all the provinces. There is real need for such investigational work in connection with the organic and inorganic constituents of soils, the nature of the complexes involved, and the nature and solubility of soil compounds. Further, there is need for the correlation of such studies with soil formation processes and studies in soil genesis and morphology.

It is natural to expect that the economic demand for information relating to land utilization and fertilization for crop production will, for a long time, require that experimental work along the soil fertility lines be given first attention. Nevertheless, it must be emphasized that the fundamental investigations necessary for the establishment of principles to be applied in soil fertility work should receive more attention than they have in the past. It is quite apparent too, that soil survey and soil classification projects are of vital importance as a basis for the organization of other systematic soil studies, whether in the laboratory or in the field. It may be said, however, that the soil investigational work now under way, as reported in the project outlines, is all necessary and important work and is, apparently, organized along the very best lines in each of the various provinces. There is an urgent need for more general recognition of the importance of soil investigations to the end that further support may be available to expand this work. This is particularly true in the case of those provinces where the work has not developed as rapidly as would be desirable.

It is realized that this general analysis of the Report must be considered only as tentative, and made without adequate time to study fully the whole field, and in the light only of the limited information contained in the project outlines.

ANNUAL MEETING OF THE SOILS GROUP OF THE C.S.T.A.

The annual meeting of the Soils Group of the C.S.T.A. was held at Macdonald College, P.Q., June 26 and 27, 1934. The programme was prepared by the officers of the Group for 1933-34 who were: Dr. E. S. Hopkins, Central Experimental Farm, Chairman; Dr. A. Leahey, University of Alberta, vice-chairman; and Dr. R. R. McKibbin, Macdonald College, Secretary. The papers and main committee reports have been assembled for this issue of Scientific Agriculture under the direction of Dr. McKibbin and Dr. Hopkins. The following officers were elected for the year 1934-35:—

Chairman—Dr. A. Leahey, University of Alberta, Edmonton, Alta.
1st Vice-Chairman—Dr. R. R. McKibbin, Macdonald College, P.Q.
2nd Vice-Chairman—Prof. August Scott, Ecole Superieure d'Agriculture, Ste. Anne de la Pocatière, P.Q.
Secretary—Dr. J. Mitchell, University of Saskatchewan, Saskatoon, Sask.

REPORT ON THE PREPARATION OF A SOIL ZONE MAP OF CANADA[1]

At the Soils Group meeting of the C.S.T.A. held in June, 1932, it was decided that the preparation of a genetic soil map of Canada should be undertaken. To this end Professor A. H. Joel of the University of Saskatchewan was appointed to undertake this work, with the aid and co-operation of a committee composed of a representative from each province. As chairman of this committee Professor Joel devoted considerable time and energy to the project, so that, in the ensuing year, excellent progress was made. At the next annual meeting the chairman reported that the committee members had submitted such provincial soil zone maps as were available, and that from these he had plotted a preliminary composite map. During the discussion of this work in committee it was decided that this preliminary composite map should be submitted to each member so that each could make a copy and thus become familiar with the information at present available.

In April, 1934, Professor Joel resigned from his position with the University of Saskatchewan, on account of ill health, and much to the regret of all the members of the Genetic Soil Map Committee, he was unable to continue the work he was doing so ably as their chairman. The writer was appointed to carry on the chairmanship of this committee in his stead.

At the next Soil Group meeting held at Macdonald College in 1934 the committee members present met and reviewed the work which had been done to date. In some of the provinces, larger areas have been covered by soil survey, and some workers have been able to do the work in more detail. Consequently there are a number of gaps which require to be filled in the general map and these require further work on the part of the individual members of the committee before the publication of a completed map is justified.

The project involves the zoning of over three and a third billion acres. It is a task of considerable magnitude, and to bring the project to completion requires the continued activity and co-operation of each committee member so that the details of each province may be available as the field work progresses.

The present chairman is compiling further information of a general character which will be sent to the various committee members for criticism and correction when the necessary compilations and sketch maps are finished.

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[1] Statement presented by Prof. J. H. Ellis of the University of Manitoba to the Soils Group of the C.S.T.A at the annual meeting at Macdonald College, P.Q., June, 1934.

A NEW TYPE OF BEE COUNTER

J. Patterson[1]

Meteorological Service of Canada, Toronto, Ontario

[Received for publication October 10, 1934]

A common method of measuring the activity of bees is to count the number that enter or leave a hive during the period under investigation. Several devices have been used to obtain this count, one of the most recent being that of the photo-electric cell, whereby the bee is made to pass through a narrow channel and interrupt a beam of light to a photo-electric cell, thereby breaking the photo-electric current. By a suitable relay this can be registered on a counter. One channel, however, is not sufficient to obtain an accurate count of the bees that enter or leave the hive. The introduction of a sufficient number of channels with photo-electric cells for each would make the expense almost prohibitive. To overcome this difficulty a photographic method was substituted for the photo-electric.

The method is simply to photograph a small spot of light on a moving photographic film so as to have a fine line traced on the film; suitable arrangements are made whereby a bee in passing through a channel interrupts this light thus making a break in the line. The number of breaks in a given time gives the number of bees that pass through the channel. As many channels as may be desired can be photographed on the same film.

The arrangement of the apparatus is shown in Plate I, and diagrammatically in Figure 1.

Figure 1 gives a diagrammatic representation for a single channel. Light from a 250 watt bulb passes through the cylindrical lens (G) and an opening (Q) at the top of the channel, and is brought to focus on a thin white paper (R) placed above the narrow slit (S). The white paper is thus strongly illuminated and a wide angle photographic lens (T) focuses this spot of light on the moving film (Y). The moving film is mounted as in a motion picture camera and travels at the rate of 8 inches per minute by means of a motor with a suitable reduction gear. The bee crossing the slit makes a distinct break in the trace. The driving wheel (L) and the guiding wheel (J) with the two spools (M) and (N) were obtained from a movie camera while the guide pins (K) are placed there so that the position

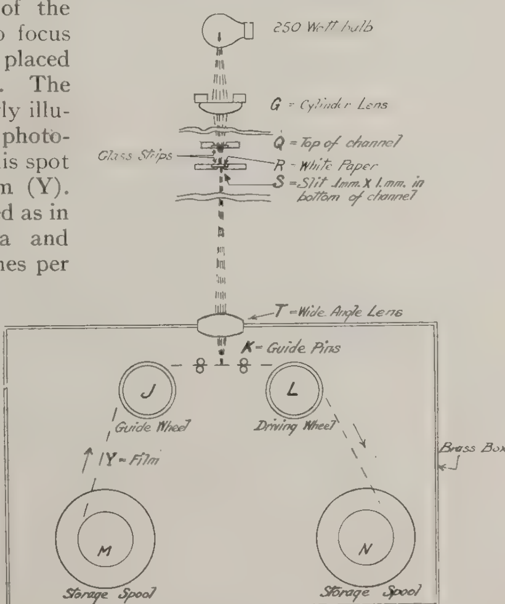

Figure 1

[1] Director.

PLATE I

1. Motor driven camera in box. 2. Hive and counter complete. 3. Entrance tunnels.

A. Camera. B. Motor. C. Camera box. D. Hive. E. Entrance tunnels. F. Gate on tunnel. G. Focussing lens. H. Lamp housing.

of the film will not be changed with reference to the focus. The film winds off spool (M) on which there is a slight tension in order to prevent the film unrolling of itself, and is stored on the spool (N). This spool is turned by a friction belt drive which is not shown.

The apparatus as actually used is shown in Plate I. (A) is the camera box, made of brass and light tight. It is so arranged that it can be easily removed, and by means of stops it is always put back into exactly the same position. The mounting of the reduction gear for the motor is shown in (B), the motor being behind the plate. A worm gear with a suitable reduction drives the small pulley shown in (B). This pulley by means of a belt drives the pulley shown above (B). This latter is connected directly to the driving wheel (L), Figure 1. By suitably arranging the reduction gear and the relative diameters of the pulleys any desired movement of the film per minute can be obtained.

A front view of the channels is shown at (E) (Plate I, Figure 3). In this particular case, there are 24 channels so arranged that the bees can leave through 12 of them and enter the hive through the alternate 12. This was arranged by means of small trap doors. The ends of the tunnels were bevelled at an angle of 45°, and a thin piece of celluloid suspended from a fine wire hinge to cover the opening. These gates could be opened only by a bee entering the tunnel from the other end. As the odd numbered tunnels had the gates on the outer end, and the even numbered ones on the inner end, they were thus made one-way passages, half being exits and half entrances.

The cylindrical lens (G) above the channel focuses the light on the thin sheet of white paper below the channel as explained in Figure 1. It was found that white paper gave the best results. To omit the paper the light was not so intense nor of so good a colour for photographic purposes. Oiling the paper did not improve it. The paper was held in position by means of a thin glass strip placed above it.

The complete mounting of hive and apparatus is shown in Plate I, Figure 2: (D) is the hive; (C) the box containing the camera and motor; (E) the channels by which the bees could enter or leave the hive, and (H) a housing for the lamps.

A positive motion picture film 35 mm. wide was used. This was very considerably cheaper than a negative film, but it required two 250-watt lamps to illuminate the white paper. This caused considerable heat, so that it was necessary to protect the hive by means of an asbestos sheet. The film travelled at the rate of 8 inches per minute and time signals were put on every five minutes by turning off the light for ten seconds. It was found that a special mark had to be put on one end of the film so as to know which end was exposed first.

By counting by eye the number of breaks in each line it is possible to obtain the total number of bees passing in or out in a given time. This counting could also be done by projecting the film on to a screen and thus enabling the count to be made more easily. This is possibly the most tedious part of the method, but it has one advantage in that it gives a permanent record which is always available for study.

This apparatus was designed in consultation with Dean W. H. Brittain of Macdonald College, for use in his studies on the activity of bees.

INHERITANCE OF SEED COLOR IN ALFALFA[1]

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[Received for publication July 13, 1934]

The extent to which normal well matured alfalfa seed may vary in color is not generally recognized. Close examination of a bulk sample or, better still, the seed from a population of individual plants, will show that while the dominant color is a bright greenish yellow, the density of color extends through a range of from very light yellow to orange or light brown. Of interest in this connection are certain exceptional plants which produced true black and true white seed. When the former were crossed with yellow seeded plants they gave F_1 hybrids which produced seeds of various shades of mulatto. It seemed worth while to investigate as far as possible the inheritance of the black and white seeded characters and to determine whether it might be feasible to use the former as a marker for identifying improved strains.

REVIEW OF LITERATURE

The literature dealing with seed color studies in general is not very extensive and this is especially true with reference to leguminous plants. Without attempting to cover all of the original papers, a brief review will be made of the more important inheritance studies relating to seed color in legumes.

The comparatively recent work on inheritance in soybeans by Woodworth, Owen, Stewart, and other investigators has been summarized by Woodworth (*5*). The efforts of these workers have shown that in the seed color inheritance of soybeans many factors are involved. The most important of these constitutes two multiple allelomorphic series, one conditioning the expression of black and brown pigments in the seed coat and the other series acting as inhibiting factors.

Hallquist (*1*) postulates the following genetical formulae for *Lupinus angustifolium:*—R, a basic factor for pure red flower color and rust brown seed color, the double recessive having white flowers and white seeds. B, a factor which, together with R, gives bluish red flowers and earth brown seeds. In the presence of R, a factor V transforms the pure red color into violet. V does not influence the seed color.

In *Vicia Faba*, Sirks (*4*) found that seed color depends primarily on a factor O. In the absence of O, whitish gray seeds are produced which are converted by Y into yellow white. O with P gives yellow, and with p purple seeds. Another factor Sc in the presence of O produces black seeds, and a factor M, causing mottling of seeds, is linked with O.

In the case of alfalfa, no studies on the inheritance of seed pigmentation seem to have been reported.

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[1] Contribution from the Division of Forage Plants. A thesis presented to the Faculty of Graduate Studies and Research of McGill University in partial fulfillment of the requirements for the degree of Master of Science.

MATERIAL AND METHODS

Black Seeded Parent and Progeny

The black seeded plant was discovered in a third generation selfed line of Grimm alfalfa. It was a good seed producer and appeared to be well developed although somewhat reduced in vigor, but not more so than other plants in the same progeny. Both selfed seed and open fertilized seed were obtained from this original black plant. It is believed that the other plants in the same line were yellow seeded but definite information is lacking on this point.

In the next generation, 20 L_4 plants were produced from selfed seed and 20 plants also from open-fertilized seed taken from the original parent. The former were dwarf, being greatly reduced in vigor and the seed of all was either black or dark mulatto, except one which produced yellow seed. The progeny from open fertilized seed on the other hand was composed of plants so exceptionally vigorous that no doubt existed as to their hybrid origin. It was definitely known that the female parent was black seeded, while the male parents were presumed to be yellow, an altogether likely assumption. The seed produced by these plants exhibited various shades of mulatto but none of them were as black as the original parent or as light in color as the average for common alfalfa. All of the seed from each plant was remarkably uniform in color. The material available to the author at the beginning of this study consisted of selfed seed from 19 F_1 plants, 11 of the L_4 plants and open fertilized seed from the white seeded plant.

One of the most serious difficulties encountered in this study was the almost complete self-sterility of the L_4 black seeded plants. Self-sterility was a characteristic of all plants in this selfed line, and it was more or less evident in some of the hybrid progeny when black seeded individuals were used as the female parent. Lack of fertility was evidently associated with loss of vigor due to inbreeding and there were indications that it may have been linked with factors which are responsible for pigment in the seed.

A study of the floral parts of these L_4 plants did not reveal anything out of the ordinary except a marked constriction of the pistil in the central region. Examination of numerous flowers of common alfalfa failed to disclose a similar constriction. It is not probable that this peculiarity affected fertilization, since F_1 seed was obtained with the L_4 plants as female parents, indicating that the ovules were functional. An examination of pollen from plants of this line showed that there was a considerable percentage of sub-normal grains and that the starch content of functional grains was less than normal, yet the amount of good pollen seemed ample to effect fertilization. Furthermore, the successful germination of these pollen grains on an artificial medium and the fact that pollen from the L_4 plants was effective in fertilizing emasculated flowers of ordinary plants, indicates that a considerable proportion of the pollen was viable.

The root-tips of these plants were examined cytologically and in all cases the normal number of chromosomes ($2n=32$) were observed, nor was there any evidence of chromosome abnormalities.

Since, as has been shown, the L_4 plants produced pollen grains and ovules which were functional and since there was no evidence of chromosome aberrations, it is evident that a case of self-incompatability obtains

in this line. It is also evident that whatever is the immediate cause of this self-incompatability, it may be regarded as one of the effects of continuous inbreeding.

Figure 1 shows the various lots of breeding material which were grown and studied. It will be observed that seed was secured from Black × Yellow, Black × White, and White × Yellow hybrids. This, in addition to the F_2 families resulting from natural hybrids between the original Black parent and normal yellow seeded plants, provided the most important data which were obtained on the inheritance of seed color.

Most of the studies which have been made on inheritance have presented a problem in classification and the present one was no exception. It was soon apparent that we were dealing with a wide range of color variability due on the one hand to blending inheritance and on the other to pronounced differences in shades of color as a result of environmental conditions.

In view of the various shades of mulatto exhibited by F_1 natural crosses from near yellow to dark mulatto, and in view of the wide range of variability due to segregation in the F_2 families produced from them (See Table 2), and furthermore the various differences in shades of color observed in a good sample of ordinary alfalfa seed, it was decided that a consistent analysis of the breeding material could be secured only by setting up an arbitrary scale of color values. Accordingly, seed samples were selected which could be used as type samples covering the entire range of color from light yellow on the one hand to dense black on the other. This resulted in a number of samples which were placed in series in as many compartments under transparent celluloid. The greatest degree of difference between any two adjacent samples was only sufficient to be recognized.

The procedure in classifying the individual plants consisted in placing the seed samples harvested from them in a sliding compartment by means of which it could be moved back and forth along the series of type samples until it was properly matched and its classification determined. It then received a number corresponding to the number of the type sample. Altogether 18 type samples were obtained, these being assigned numbers from 1 to 18, indicating the range in color from very light yellow to black.

Very light yellow seed samples occurred quite frequently which appeared to be at least one distinct shade lighter in color than a bright, well matured sample of ordinary alfalfa. The so-called black seed was not a coal black but rather what might be described more correctly as a deep purplish black. The casual observer, however, would designate the color as black. The pigment was definitely located in the seed coat. Between yellow and black, as previously stated, were various shades of mulatto which graded into each other insensibly; that is to say, there were no distinct lines of demarcation which could be recognized.

To insure accuracy of classification all seed samples were examined twice by daylight and then under an electric fixture, which provided a uniform source of illumination. Finally all samples having the same color number were examined together and compared with one another. Any samples deviating significantly from the type sample of the group were reconsidered with respect to classification. When samples were available from the same plant representing seed produced by it in more than one

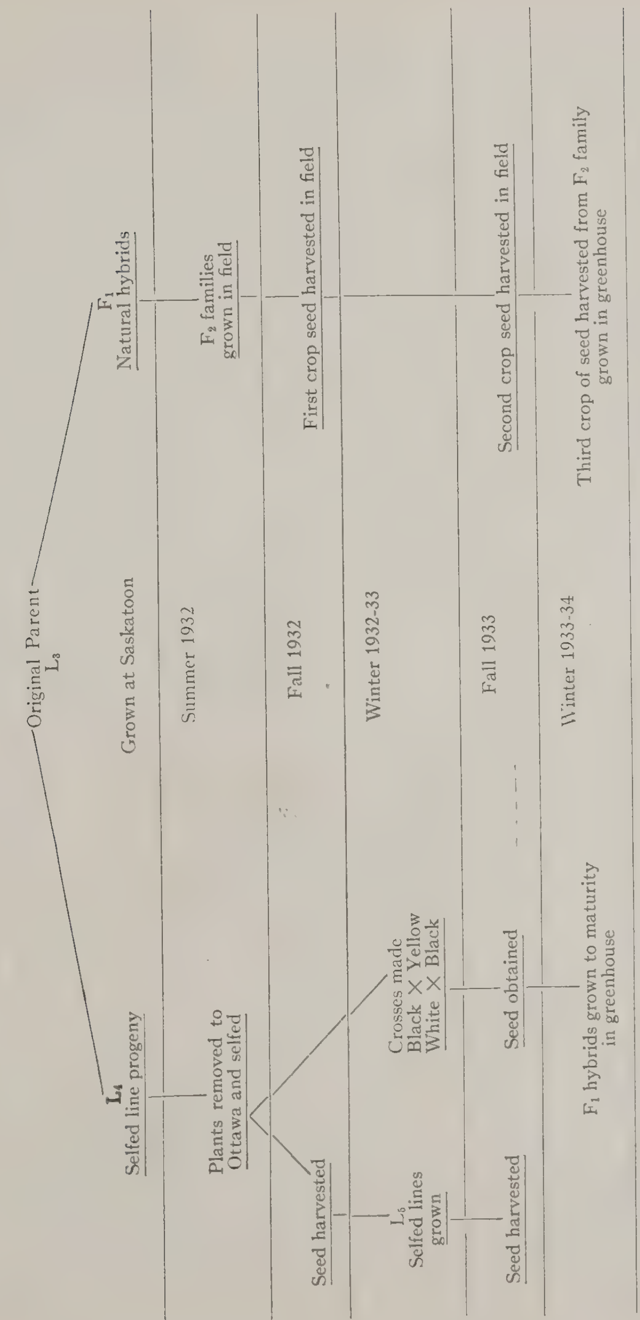

FIGURE 1. Outline of experimental procedure showing the main lines of descent in the inheritance study of seed color in alfalfa.

season or in the greenhouse, the darkest color was considered to be closest to the correct classification for that particular plant.

The lack of color differences sufficiently definite to form distinct color classes was the chief justification for establishing as large a series of color types as possible. It was recognized that these color classes should not be expected to correspond to as many phenotypes but it was thought that many rather than few sub-divisions of the color range would make for greater accuracy of classification. This was undoubtedly the case. Moreover, the procedure which was adopted permitted of any system of grouping found to be most appropriate in the light of the data as a whole.

In the first place, consideration had to be given to the degree of variability in color and its probable cause as between seed on individual plants matured in a single season, as between plants grown in the same season, and also as between the same plants grown in different seasons or in the greenhouse.

Seed color of F_1 natural hybrids in 1931 exhibited wide differences as between plants, a fact that will merit further discussion, but examination of these showed remarkable uniformity within each sample. These plants matured under ideal weather conditions in Western Canada. Uniformity was less striking in single plant samples harvested at Ottawa in 1932 and 1933. There remained the question, therefore, as to whether or not the density of color might not be influenced to some extent by weather conditions which preceded maturity of the seed. There was also the possibility that seed color might become intensified between the time that the pods first appeared to be ripe and the time that the seed was harvested. This is a matter of some importance since pods taken from plants in the field will not all have matured at the same time. An attempt was made to settle this point by growing a number of plants in the greenhouse under controlled temperature and illumination. Each pod was labelled when it first appeared to be ripe and seed samples having the same date labels were harvested thereafter at intervals of two or three days. Comparison of these samples of seed demonstrated that the color had reached its full expression when the pods had turned brown and that it did not change materially after that time. Seed produced on single plants in the field, however, matures over a considerable period of time during which atmospheric conditions may be anything but uniform. There is the probability therefore that atmospheric conditions in the field may be responsible for more or less variability in seed color produced by individual plants matured at different dates in the same season.

It was equally difficult to determine the degree to which color intensity may vary as between plants of the same genetic constitution grown in the same season, for the reason that environmental effects on seed color could not be divorced from genetic effects. It would seem that the influence of climatic conditions in these cases should not be much greater than in the case of seed from pods taken from the same plants at different times as they reach maturity. What evidence there was indicated that such effects were not very marked but probably sufficient to increase very materially the difficulty of making an accurate genetic classification of the material.

The greatest degree of variation in color was found to occur between seed samples taken from the same plants in different seasons. Seed was

harvested in both 1932 and 1933 from the same plants and in the case of one large F_2 family they were then taken from the field and propagated in pots in the greenhouse with artificial illumination during the winter of 1933-1934. The seed produced under all three environmental conditions by each plant was then classified according to the arbitrary scale of color values and each was assigned the number corresponding to the type sample which it resembled most closely. Of 102 plants tested in this way, the seed samples from 18 plants were classified under a single color type, 47 under two, 25 under three, while 12 plants varied in color by as many as four shades in the color series.

White Seeded Parent and Progeny

The white seeded plant was found in the alfalfa breeding nursery at the University of Saskatchewan. It was one among many plants of the Grimm variety which were being harvested individually for seed. This plant had white flowers and the seed was wholly lacking in yellow pigment. Lack of color in both flowers and seeds indicated that in all probability the plant was homozygous recessive with respect to pigmentation. Open-fertilized seed was secured but the plant itself has not been available for this study.

In the spring of 1932, a progeny of 80 seedlings were grown in the greenhouse at Ottawa from this white alfalfa seed. These were transplanted into the field early in the spring. The plants flowered and produced seed the first season. Among these were found two white flowered and white seeded plants. It was assumed that these came from selfed seed and that the remaining 78 plants represented F_1 hybrids, the result of natural crossing between the original white seeded plant and normal yellow seeded individuals. All of the plants with colored flowers produced yellow seed, a fact which argues for the theory that the original parent was a double recessive.

In the fall of the year the two white-flowered and white seeded plants grown at Ottawa in 1932 were transplanted into pots and removed from the field into the greenhouse. One of these (W.S.1) proved to be completely male sterile. Examination of the pollen showed that it was non-functional. The other plant (W.S. 2) gave a few selfed seeds from which eight plants were obtained, all of which produced colorless flowers and seeds, a further indication of the homozygous recessive character of the colorless condition.

Although W.S.1 was male sterile it produced seed readily when fertilized with the pollen from other plants, and because it was unnecessary to emasculate the flowers, this plant was used, rather than W.S.2, in most of the crosses with yellow seeded and black seeded plants as male parents.

In 1932 a large number of the plants were selfed which had been grown from open-fertilized seed taken from the original white seeded parent. It was assumed, with considerable justification, that those which had produced colored flowers and seeds were White $\times$ Yellow natural F_1 hybrids. In the spring of 1933 about 900 seedlings comprising 10 L_2 families were transplanted into the breeding nursery. Under normal conditions this material would have flowered and produced some seed the first season, thus providing definite information on the genetics of the white seeded character. Unfortunately this alfalfa nursery was severely attacked by

leaf hoppers. Although the plants were saved by repeated treatments with insecticide, the growth was retarded to such an extent that the plants failed to set seed and a large proportion of them failed to bloom. Of those which blossomed a considerable number had white flowers but it was impossible to secure reliable ratios.

Breeding Behaviour:

Figure 2 shows the results obtained in two successive generations from selfing the parent plant. Figures in brackets indicate the color type. In the first generation from selfed seed (L_4) 20 plants were obtained of which 11 produced seed. Ten of these varied in color from 14 to 18 and one produced yellow seed. This is evidence for the heterozygous character of the parent.

Repeated attempts were made to obtain selfed seed from the L_4 plants both in the field and in the greenhouse. In all, approximately 8,000 flowers were tripped artificially. Seed was obtained from only four plants and the resulting progenies contained a total of only 47 individuals. The color classification of seed produced by the L_5 plants in relation to the L_4 progeny and the original parent is shown in Table 1.

TABLE 1.—CLASSIFICATION OF THE ORIGINAL L_3 BLACK SEEDED PARENT AND THE FOURTH AND FIFTH GENERATION SELFED LINES, ACCORDING TO TYPE SAMPLES

Designation of plants	Seed color classes																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
L_3																		1	1
L_4				1										2	3	1	2	2	11
L_5 (B2)		2																	2
L_5 (B8)						2		1	1		3	1	1			1			10
L_5 (B12)					2	3	7				1								13
L_5 (B13)					2	5	3	3		2	3	3	1						22

With reference to Table 1 it is worthy of note that selfed seed was easily obtained from the original L_3 parent while the L_4 plants were almost or completely self-sterile. The difference in this respect can be accounted for by the fact that the L_3 plant was reasonably vigorous and well developed, whereas all of the L_4 plants were much reduced in size and decidedly lacking in vigor of growth. Kirk (2) has shown that inbreeding has a very pronounced effect on seed production, so much so that the majority of selfed lines produce very little seed in the fourth generation and many of them are completely sterile. He has shown also that pronounced loss of vigor may take place in any generation. In this case it occurred in the fourth.

In view of the high degree of self-sterility exhibited by the L_4 plants, it seems altogether probable that the 47 plants reported in L_5 may have resulted from accidental fertilization with foreign pollen. Their position in the color series (see Table 1) strongly suggests that they are F_1 Black $\times$ Yellow hybrids rather than fifth generation selfed lines. This number of accidental hybrids from some 8,000 flowers which were tripped might

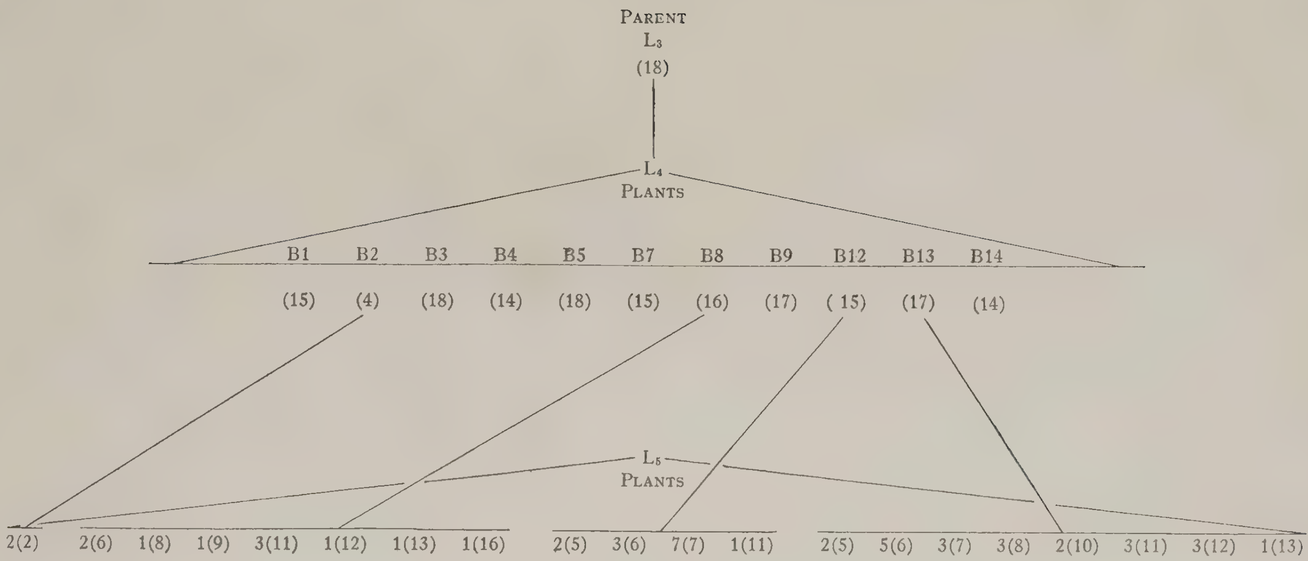

FIGURE 2. Distribution with respect to seed color of fourth and fifth generation inbred progenies from the original black seeded parent plant. (Seed color classes in brackets.)

occur even with the best of technique. At any rate it is safer to disregard these plants when considering the data.

One other feature of Table 1 that is of interest, is the occurrence of the single yellow seeded plant classified under 4. There is little doubt that this individual properly belongs in the L_4 selfed line since it was dwarf and otherwise similar to the other plants in appearance. As will be seen, it is not so difficult to account for this plant as for the absence of individuals in the color series from 5 to 13 inclusive. The smallness of the population, however, must be taken into consideration.

Table 2 shows the distribution of F_2 plants in relation to the color series. These families are the progenies of F_1 hybrids obtained from crosses between the original black seeded parent and normal yellow seeded plants. It is important to note that the male parents are not necessarily the same for any two families.

TABLE 2.—CLASSIFICATION OF F_2 FAMILIES, ACCORDING TO TYPE SAMPLES

F_2 families	Seed color classes																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1		1		2	2	1	2		4	4	**4**	2							22
2	1	8		13	7	**6**	6	9	12	3	4	1							70
3		1		4	**13**	15	12	9	16		1								71
4			1			1	**2**		2	2									8
5	2	1	1	16	6	**1**	12	3	11	4									57
6				3		3	**2**	7	8	4		1							28
7	16	4	3	12	9	22	27	**5**	43	47	17	5	4	2					216
8	4		1	6		3	4	3	**23**	16	5	3							68
9	1			2		10	8	12	**15**	11	3	5	1			1			69
10			1	4	1	1	3	3	3	2	3	**8**	6	3	2	2	3	4	49
11				1	1	1	2	1	1	1	4	**2**	1	3	1				19
12	10	2		7	6	4	19	**8**	20	6	2	2	2		1				89
13	4	1			1	7	8	4	10	**8**	8	7	7	5	2	2		3	77
14	5	2	1	2	2	4	12	3	**12**	11	3	2	2						61
15	3		4	19	12	25	47	17	127	**117**	61	49	13	2	1	1			498
16	1		1	5	2	9	**16**	5	9	5	2	1							56
17			2	2	1	**14**	30	3	4	2	1								59
18				1	2	3	5		**3**	2	4		1		1				22
19	5	1			2	16	17	**4**	10	4	1	1							61
																			1,598

NOTE.—Heavy figures indicate the color classification of the F^1 parent of each family.

Heavy figures indicate the color classification of the F_1 parent of each family. The F_1 hybrids obviously must have been essentially different with respect to genetic constitution in order to account for the pronounced dissimilarity of F_2 progenies in the distribution of individuals. These peculiarities of family behaviour in breeding must be attributed to the heterozygosity of the female parent, and probably also to differences in the genetic constitution of the male parents.

An interesting and very significant feature of Table 2 is the deficiency of black and dark mulatto seeded plants. Only two families produced black seed and only 24 plants out of approximately 1,600 are classified in the four darkest groups. Even in the color range above 12, at which point there appeared to be a transition from medium to dark mulatto,

there are only 77 plants. This fact strongly suggests that most of the plants in the range of darkest seed color have been eliminated by a factor or combination of factors which produce gametic or zygotic lethal effects.

Table 3 shows the distribution of F_1 hybrid plants with respect to seed color from Black × Yellow crosses. The first horizontal row contains the F_1 hybrids obtained by fertilizing the original black seeded plant with pollen from yellow seeded parents, while B_1, B_2 - - - B_{14} are the L_4 plants shown in Table 1. As might be expected, many of the hybrids are located in the intermediate color classes from 9 to 12 inclusive, indicating that there is a blending of color inheritance, but on the other hand it is difficult to account for the disproportionate numbers which are classified as 5, since this color class corresponds closely to what may be regarded as normal yellow. The distribution resulting from L_3 Black × Yellow F_1 plants approaches much more closely to what might be expected from Mendelian segregation than does that of any of the L_4 Black × Yellow hybrid groups.

TABLE 3.—CLASSIFICATION OF F_1 HYBRIDS FROM BLACK × YELLOW CROSSES ACCORDING TO TYPE SAMPLES

Crosses	Seed color classes																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
L_3 B1 × Y					1	3	3	3	4	2	1	2							19
L_4 B1 × Y				4		5	1	4	3	1	4	1							23
L_4 B2 × Y		1			12	6													19
L_4 B4 × Y					3	1	2		1										7
L_4 B5 × Y					3	2	2		3										10
L_4 B8 × Y					6	3		3	7										19
L_4 B9 × Y					1			4	10	2	4								21
L_4 B12 × Y					18		2		4		2	3							29
L_4 B13 × Y					3		3	1	2		10	3	1	1					24
L_4 B14 × Y								1	2		1	3							7

Table 4 gives the distribution of F_1 hybrids from crosses between the white seeded plants previously referred to (W.S.1 and W.S.2) and the same black seeded L_4 plants which were used as female parents in Black × Yellow crosses (see Table 3). The crosses listed in Table 4, however, had the white seeded plants as female parents. Reciprocal crosses were not possible since the latter were male sterile.

The distribution of F_1 individuals in Table 4 is similar to that in Table 3, except that in the former a large group of plants occur in the color series under 1 and 2, whereas they are wholly absent in Table 3. These color types correspond to a very light shade of yellow which is not commonly found in a well matured sample of alfalfa. Since there is little doubt that the female parents were homozygous recessives with respect to pigmented seeds, it is reasonable to assume that those plants which fall in groups 1 and 2 are heterozygous for the factor or factors which condition the normal yellow seed color. The sharp distinction between light yellow, corresponding to types 1 and 2 in the color range, and typical yellow corresponding to types 4 and 5 is very conspicuous.

In Table 4, as in Table 3, the complete absence of black and the darker shades of mulatto in the color series from 13 to 18 inclusive, as well as the decided tendency toward skewed distributions toward the yellow end of the series, are considerations worthy of note. It would appear also that in Table 4 the largest frequencies from White × Black crosses occur in color types 9, 10 and 11, while those in Table 3 from Black × Yellow crosses are found under color number 5, which is yellow.

There is one other observation in Table 4 that baffles explanation on any theory of Mendelian inheritance. This is the fact that W.S.$_1$ × B_2 gave two F_1 hybrids which were classified under 11 in the color series. B_2 is the yellow seeded L_4 segregate from the original black seeded plant and W.S.1 lacks both the black and yellow pigment. It is difficult to understand how this union could possibly result in offspring with mulatto colored seed coats. It is instructive to compare the distribution of F_1 plants from this cross with that of the B_2 × Yellow cross in Table 3, since the same L_4 yellow seeded segregate was used in both. In the latter case no plants were found which would classify above 6 in the color series.

TABLE 4.—CLASSIFICATION OF F_1 HYBRIDS FROM WHITE × BLACK CROSSES ACCORDING TO TYPE SAMPLES

Crosses	Seed color classes																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
WS1 × L_4B_2	12	1				2	1				2								18
WS1 × L_4B_4	7	3			1		3		1	6	6								27
WS1 × L_4B_5					1	2		2		1	4								10
WS1 × L_4B_8	1	3			4			3	9	1									21
WS2 × L_4B_8	3			2	1		1		4										11
WS1 × L_4B_9	7	2		2	3	1		3	4	16	13	3							54
WS1 × L_4B_{12}	8	3		3	4	1	6	2	4	5	10	4							50
WS1 × L_4B_{13}	2				1	1	3	1	3	7	4								22
WS2 × L_4B_{13}					3						2								5

Discussion of Results

There are two ways in which the original black seeded plant may have originated. Black-seededness may have appeared as a result of repeated selfing since it was found in a third generation selfed line; or it may have arisen as a mutation in the parent plant one generation before. Under the first assumption it is necessary to postulate that the black color was carried along in the heterozygous condition and that it found expression only when the factors which conditioned this character had reached homozygosity. It is apparent from the data that the original plant did not breed true for the character in question.

If black-seededness appeared as the result of mutation it is unlikely that the mutation occurred at more than one locus. It is reasonable to expect, therefore, that the plant would be heterozygous for the factor responsible for this character. This was found to be the case, which argues for the theory of origin by mutation. It presupposes that black-seededness was due primarily to a single factor difference.

It is obvious from the distribution of plants in F_2 families that if a monofactorial mutation was responsible for the appearance of black or dark purple pigmentation in the seed of the original parent plant, this change in the genetic constitution does not provide an adequate explanation of the type of segregation which was obtained. The distribution of individuals is such as to suggest a fairly complex type of inheritance requiring the assumption of two or more modifying factors to account for the variability in seed color. Thus at least three genetic factors would be involved, and quite possibly more, in the inheritance of black-seededness. In addition there is certainly at least one factor for yellow in the homozygous condition which is responsible for the yellow pigments of normal alfalfa seed. The absence of this factor or factors results in white seed.

According to this analysis of seed color inheritance the factorial constitution of the original black seeded parent may be written YY C_1c_1 C_2c_2 Bb where the genes are represented by Y for yellow pigment, B for black pigment, and C_1 C_2 for factors which modify the expression of the black color. It is necessary to assume heterozygosity for the three factors responsible for black and mulatto because the presence of factors in the homozygous condition would not alter the picture. The number of modifying factors, however, could be postulated as three instead of two with equal justification.

It is not possible with the available data to arrive at a genetic formula which is entirely acceptable. The single factor mutation for black seems to be a logical assumption. It is not unreasonable to expect that modifying factors should affect the expression of this character. A seed sample of ordinary alfalfa exhibits a wide range of color variation which in all probability has a genetic basis. In most of the seed color studies with leguminous plants, modifying factors have been found to play a prominent part. On the other hand, while the three factor hypothesis fits the facts reasonably well there are certain features of the data which are difficult to harmonize. Some of these are doubtless due to variation as the result of environmental effects which influence the physiology of the plant. Assuming, however, that the genes are complementary and their effects cumulative, the suggested genetic complex provides a fairly satisfactory hypothesis as a possible explanation. The most serious discrepancies in the data are the deficiency of black and dark mulatto seeded plants in F_2 families and the occurrence and breeding behaviour of the yellow seeded L_4 segregate previously mentioned. The deficiencies can only be accounted for by assuming that these plants have been eliminated by gametic or zygotic lethals.

There is considerable evidence to indicate that pigmentation of the seed coat may be profoundly influenced by physiological factors.

An interesting case in point is that of seed-coat mottling in soybeans which has been studied superficially by many workers. Enough has been done to show that plant physiology assumes the major role in this phenomenon. Inheritance undoubtedly plays a part but most yellow or green seeded varieties are subject to mottling under certain environmental conditions. Heredity is undoubtedly the ultimate controlling factor, but mottling is apparently inhibited except under those peculiar conditions which make the expression of this character possible.

Owen (*3*) discusses this question rather fully and refers to the work of Onslow who found, among other things, that some species formed starch and others did not. To quote: "The interesting point in this connection is the high negative correlation that was found between starch and pigment formation. In species that were not able to synthesize starch, sugars accumulated; and since sugars are used in the formation of anthocyanins, a logical reason can be given for pigmentation. Plants that were able to form starch, she assumes, made use of their sugars in that process, and the quantity of sugar left was insufficient for the production of pigments." Since the black and brown pigments which are primarily responsible for mottling were found to be glucosides, an explanation of their production by means of an accumulation of sugars has been proposed by Owen. He found the most striking evidence for this theory in his observations that mottling was greatly increased by reviving the growth of plants after the seeds were practically mature. Also it was found that mottling varied on different parts of the same plant.

In the case of pigmentation of seed in alfalfa there is no doubt as to the dominant part played by hereditary factors. At the same time there is reason to believe that physiological factors influenced the development of pigment to a greater or less extent. If this were the case, a satisfactory explanation of the data on breeding behaviour would become extremely difficult. At the same time it would provide a partial answer for some of the discrepancies which were found in an attempt to compare the results with genetic expectations.

If, for instance, we accept Owen's (*3*) suggestion and assume that the original black seeded parent plant not only carried a factor for black-seededness but also that it lacked the normal power of synthesizing starch, its behaviour in breeding would depend as much on the type of inheritance exhibited by the latter as by the former. Assuming segregation in both cases to be regular, normal Mendelian ratios would still be expected, the factor or factors for "starch formation" simply acting as color determiners or modifiers. But if the inability to form starch was also conditioned by vigor of growth, as appears to be the case with seed production, then the least vigorous plants would tend to have pigmented seed provided they also possessed the necessary inheritance. Conversely, the most vigorous plants would tend to produce seed with the minimum amount of pigment. The segregation obtained in F_2 would then be influenced by the degree of heterozygosity of individual plants in each family as well as by the random assortment of factors which condition seed coat color. This hypothesis could be used quite effectively to explain the distributions obtained in F_2 families, the marked deficiency of dark seeded plants in Table 2 and the unexpected types of F_1 plants secured from the W.S.1 $\times$ L_4, B2 crosses in Table 4. It would also help to explain why such a large proportion of the F_1 plants in Tables 3 and 4 occur at the yellow end of the color series.

Once it is established that physiological causes are operative in modifying the expression of a character, the difficulty of a satisfactory solution to the problem is greatly increased and the opportunities for speculation are numerous. Most of the seed color studies with leguminous plants have run into this difficulty and the present study is no exception in this respect.

One of the objectives in this investigation was to determine whether it might be possible to utilize seed coat pigmentation in alfalfa as a character for identifying an improved strain. Such a distinguishing feature might some time prove very useful because of the fact that varieties of alfalfa are so similar in appearance. Its utilization for this purpose, however, could be practical only if the character were inherited in a simple manner and preferably as a double recessive. Inheritance in this case has been shown to be fairly complex with the further probability that physiological factors affect the expression of the character. Furthermore it was not possible to secure fertile homozygous black seeded plants because of self-incompatability which characterized all of the inbred plants in this line. It was concluded therefore that the character in question was valueless from a utility standpoint.

Summary

1. This paper presents the results of an investigation to determine the inheritance of black and white seed coat characters in alfalfa and whether or not the former could be utilized in breeding as a marker for identifying improved strains.

2. The black seeded plant was discovered in a third generation selfed line of Grimm alfalfa and the white seeded plant occurred in a population of Grimm alfalfa plants which had not been inbred.

3. The fourth generation selfed line from the original black seeded parent consisted of 20 plants all of which, except one which had yellow seeds, produced either black or very dark mulatto seeds. A similar number of F_1 natural hybrids, between normal yellow seeded male parents and the original black seeded plant, produced seed which varied in color from light to dark mulatto. The results obtained from numerous Black × Yellow and White × Black crosses were reported.

4. Each of 19 F_2 families of the Black × Yellow cross exhibited a wide range of variability with respect to seed coat color extending from yellow on the one hand to fairly dark mulatto on the other. With the exception of two families there was a marked deficiency of plants in the very dark color classes.

5. The available evidence indicated that the white seeded parent was homozygous for a recessive factor which results in the absence of yellow pigment, and that the inheritance of this character was comparatively simple. Inheritance of the black seeded character, on the other hand, was fairly complex, requiring the assumption of at least three factor pairs. The original black seeded plant was thought to have arisen as a single gene mutation. This gene, primarily responsible for pigmentation of the seed coat, together with at least two modifying factors were postulated as the most probable genetic factorial basis to account for the breeding behaviour of the original black seeded parent.

6. The data strongly suggest that the expression of seed coat color was influenced to some extent by physiological factors which were conditioned by the environment.

7. It was concluded that the character of black-seededness would be valueless from a utility standpoint.

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ETUDE COMPARATIVE DE QUELQUES FROMAGES RENFERMANT LE PENICILLIUM GLAUCUM[1]

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INTRODUCTION

Il existe sur le marché canadien quelques fromages d'importation, très analogues au point de vue de leurs propriétés organoleptiques; tels sont: le Grove City américain, le Stilton anglais, le Roquefort français et le Gorgonzola italien. En effet, ces divers fromages possèdent en commun les caractères suivants: ils sont à pâte fermentée et ferme; ils contiennent des marbrures verdâtres; ils développent une odeur rance et une saveur "poivrée" caractéristique.

Les marbrures sont produites par les ramifications d'un champignon microscopique, le "*Penicillium glaucum*" dont on ensemence le caillé avant la mise en moule et ultérieurement le fromage, lorsqu'on désire favoriser son persillage et activer sa maturation.

L'odeur et la saveur caractéristiques du Roquefort et des fromages similaires avaient été d'abord attribués aux spores et aux filaments fructifères du champignon. Le principe chimique de l'arôme était apparemment le butyrate d'éthyle. Mais l'expérience démontra d'une part, que le *Penicillium glaucum* cultivé sur milieu artificiel ne produisait rien de la saveur particulière du Roquefort, même en plein stade de sporulation, et que d'autre part, le fromage ne renfermait pas de butyrate d'éthyle. Il fallait donc rechercher la cause ailleurs. Currie (*2*) qui fit une étude spéciale sur le sujet, arriva aux conclusions suivantes:

"(1) During the ripening of Roquefort cheese a considerable amount of the fat is hydrolysed;

(2) *Penicillium roqueforti* (*glaucum*) produces a water-soluble lipase, which is the chief factor in the accomplishment of the hydrolysis;

(3) The hydrolysis results in the accumulation of the acids of milk fat in both the free and combined forms;

(4) Of these acids, caproic, caprylic, and capric and their readily hydrolyzable salts have a peppery taste and are responsible for the characteristic burning effect of Roquefort cheese upon the tongue and palate."

En conséquence de ce qui précède, les fromages analogues au Roquefort et contenant le *Penicillium glaucum* doivent fournir à l'exemple de ce dernier, des acides volatils en proportion comparativement plus forte ou plus faible selon que leur goût est plus ou moins accentué. D'autre part, si ces acides libres ou combinés sous la forme de sels minéraux, sont réellement libérés des glycérides par un processus hydrolytique, on doit observer simultanément une augmentation de l'acidité totale et une élévation de l'indice d'iode de la matière grasse. Car, contrairement au rancissement par auto-oxydation (à la suite d'une période d'induction plus ou moins

[1] Préliminaire d'une étude entreprise en coopération par le Département de l'Industrie Laitière de Washington, D.C., et l'Institut Rosell de Bactériologie Laitière, Inc., Oka, P.Q.

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longue), le rancissement par hydrolyse épargne les liaisons éthyléniques. La faculté d'absorption de l'iode n'étant pas amoindrie, l'indice de celui-ci qui est relatif à un poids constant de matière grasse, doit nécessairement subir une augmentation.

Le présent travail dont les résultats préliminaires apparaissent ci-après, a été entrepris dans le but de vérifier les conclusions relatives au Roquefort ainsi que les considérations théoriques qui viennent d'être faites au sujet du Grove City, du Stilton et du Gorgonzola. Comme cette étude est envisagée d'un point de vue comparatif, il était nécessaire de déterminer d'abord la composition et le rapport de maturation des spécimens d'expérience, afin d'être en mesure d'effectuer les comparaisons sur une base uniforme de référence.

METHODES D'EXPERIMENTATION SUIVIES

Détermination des principaux constituants:

L'échantillonage et les déterminations de l'humidité et des cendres ont été effectués selon les méthodes officielles de l'A.O.A.C. (pages 238 et 239 (*1*).

Pour obtenir les protéines totales, on dosait l'azote d'après la méthode Kjeldahl-Gunning sur des prises d'essai de 2 grs et on utilisait le facteur de conversion 6.38.

Pour doser la matière grasse on s'est servi de l'appareil Soxhlet à épuisement continu. Le fromage était broyé au mortier avec du sable calciné et soumis à une extraction à l'éther de 14 heures. L'extrait gras était évaporé, desséché à poids constant à 100° C et pesé. Les déterminations portaient sur des prises d'essai de 5 grs. L'extrait gras était ensuite conservé dans l'exicateur à $CaCl_2$ pour servir aux essais ultérieurs.

A titre comparatif, deux déterminations de gras furent également faites d'après la méthode Babcock, utilisant à cet effet des échantillons de 9 grs et des éprouvettes à crème de 18 grs. Les résultats obtenus par cette méthode furent sensiblement les mêmes; étant inférieurs de 0.1 à 0.2%.

Les principaux constituants, c.à.d.: eau, protéines totales, matières grasses, cendres, ont été déterminés en duplicata, sur des échantillons bien représentatifs, et d'une manière identique dans tous les cas.

Tableau 1—Composition centésimale

	Eau	Protéines	Graisses	Cendres
Grove City	37.53	21.50	31.25	6.0
Roquefort	36.90	21.33	31.20	6.9
Gorgonzola	38.15	23.33	30.81	5.5
Stilton	35.43	23.51	31.50	4.2

Les résultats rapportés à 100 grs de fromage sont compulsés dans le Tableau 1.

Détermination de l'acidité.—Le pH a été apprécié par colorimétrie à l'aide d'un indicateur LaMotte et de bromothymol-bleu; ce dernier servait à préciser les chiffres de la région supérieure à pH 6.

L'acidité totale a été déterminée par la méthode officielle de l'A.O.A.C. (page 239 *(1)*).

Les chiffres de l'acidité ionique et de l'acidité totale figurent au Tableau 2.

TABLEAU 2—ACIDITÉ

	pH	cc. N/10 NaOH pour 100 grs.
Grove City	4.0 ± 0.1	184
Roquefort	4.5 ± 0.1	146
Gorgonzola	6.0	108
Stilton	6.2	105

Détermination des acides gras volatils.—Les acides gras volatils totaux et libres ont été dosés d'après la méthode de F. Edelstein et E. Welde, modifiée par McCanchey (*6*). On appliquait la méthode de la manière suivante: 20 grs de fromage étaient broyés avec 250 cc. d'alcool à 96°. On chauffait le mélange jusqu'à ébullition dans un matras muni d'un régrigérateur ascendant. On jetait sur un filtre et on lavait le résidu avec de l'alcool bouillant. Le filtrat était divisé en deux parties égales et chacune d'elles était traitée avec une solution étendue de NaOH jusqu'à réaction légèrement alcaline, puis évaporée à siccité sur le bain-marie à 60° C. Le résidu saponifié était repris par l'eau, additionné de 10 cc. H_3PO_4, gr. sp. 1.12, puis distillé à la vapeur sous pression réduite pendant $2\frac{1}{4}$ heures. On s'assurait de la bonne marche de la distillation à l'aide du réactif au molybdate d'ammonium. Une portion aliquote du distillat était titrée avec N/10 NaOH en présence de phénolphtaléine.

Pour obtenir la fraction des acides gras volatils libres, on distillait par le même procédé, une suspension aqueuse de fromage non additionnée de H_3PO_4. On titrait comme précédemment. La différence entre les deux résultats correspond aux acides gras volatils combinés, c.à.d., neutralisés par NH_3 et les bases mobilisées au cours de la fermentation du fromage.

Les résultats exprimés en grammes d'acide butyrique par 100 grs de fromage sont réunis dans le Tableau 3.

TABLEAU 3—ACIDES GRAS VOLATILS ET ACIDE LACTIQUE POUR 100 GRAMMES

	Ac. gras vol. totaux	Ac. gras vol. libres	Ac. gras vol. combinés	Ac. lactique
Grove City	1.3060	0 8448	0.4612	0.034
Roquefort	0.4279	0.1084	0.3195	0
Gorgonzola	0.3450	0	0.3450	0
Stilton	0.3437	0	0.3437	0
		en acide butyrique		

Détermination de l'acide lactique. L'acide lactique a été déterminé par la méthode proposée par P. Léone et B. Tafuri (*4*). Cette méthode est basée sur l'oxydation de l'acide lactique à l'état d'acétaldéhyde et sur la conversion de cette dernière en oxime.

On procédait de la façon suivante: l'acide lactique étant très soluble dans l'eau, on faisait une macération de 20 grs de fromage dans 150 cc. d'eau. On jetait sur un filtre et l'extrait aqueux était utilisé pour la recherche et le dosage. Pour la recherche, on employait 10 à 20 gouttes d'extrait et 10 cc. de réactif d'Uffelmann; eau phéniquée à 4%, perchlorure

de fer officinal, 1 goutte (5). Tous les fromages ont donné une réaction négative ou non-concluante. Malgré cela, l'on a quand même procédé à la détermination quantitative en ayant soin d'employer une solution très étendue d'hydroxylamine.

L'extrait aqueux contenant l'acide lactique était introduit dans un appareil type Kjeldahl avec 100 cc. H_2SO_4 à 50% et on distillait pendant une heure à 140-150° C. Le distillat était recueilli sur une solution N/100 d'hydroxylamine dans laquelle NH_2OH avait été mise en liberté au moyen d'une solution de NaOH d'un titre correspondant à une réaction exactement neutre à la phénolphtaléine:

$$NH_2.OH.HCl + NaOH = NH_2.OH + NaCl + H_2O$$

Pendant la distillation on faisait passer dans l'appareil un faible courant d'air, utilisant pour cela la trompe à eau. On obtenait ainsi l'oxime:

$$NH_2OH + CH_3CHO = CH_3.CH{:}N.OH + H_2O$$

L'excès de NH_2OH était ensuite titré avec N/100 H_2SO_4 en présence de méthyl orange. La différence entre ce résultat et celui obtenu par un essai à blanc correspond à NH_2OH combinée, et par conséquent à l'acide lactique.

L'expérience a été conduite avec beaucoup de précaution. Chaque type de fromage a fait l'objet de deux ou de trois déterminations et les résultats furent concordants, toujours négatifs pour le Roquefort, le Gorgonzola et le Stilton, tandis que le Grove City a fourni 0.033 et 0.035 gr. d'acide lactique par 100 grs de fromage.

J'ai néanmoins l'intention de reprendre le dosage de l'acide lactique en suivant concurremment la méthode ci-dessus décrite qui date de 1931, les méthodes de T. F. Friedmann, M. Coronio et P. A. Shaffer (1927) et de A. Meyer (1933).

Détermination de l'ammoniac.—Le dosage de NH_3 a été effectué de la manière habituelle. Des macérations de fromage à 10% étaient décantées sur filtre. Une partie du filtrat était saturée par MgO, puis soumise à la distillation. L'autre partie était distillée telle quelle. Dans les deux cas, on recueillait le distillat dans N/10 H_2SO_4 et on titrait l'excès d'acide avec N/10 NaOH en présence d'hélianthine. On obtenait ainsi NH_3 total et NH_3 libre, respectivement. La différence entre les deux résultats donnait l'ammoniac des sels ammoniacaux. Le Tableau 4,

TABLEAU 4—AMMONIAC TOTAL ET LIBRE (POUR 100 GRAMMES)

	NH_3 total	NH_3 libre	NH_3 combiné	Rap. ammoniacal
Grove City	0.365	0.187	0.178	1.050
Roquefort	0.348	0.178	0.170	1.047
Gorgonzola	0.512	0.322	0.190	1.694
Stilton	0.302	0.170	0.132	1.287

groupe les résultats exprimés en gramme pour 100 grs de fromage. Ce tableau comprend aussi le rapport ammoniacal, lequel augmente avec le degré de maturation.

Détermination de l'absorption de l'iode et de la chaleur de bromination.—L'extrait éthéré ayant servi à la détermination du gras, et maintenu à l'exicateur, était utilisé pour la mesure de l'indice d'iode et de la chaleur de bromination. L'indice d'iode était déterminé de la façon habituelle, sur des prises d'essai de 0.4 à 0.55 gr.

On mesurait la chaleur de bromination sur des prises de 1 gr. d'extrait gras, en suivant la méthode de Gill et Hatch (*3*). On employait à cet effet, 5 cc. de $CHCl_3$ et 5 cc. de la solution chloroformée de brome.

Les indices d'iode calculés en partant de la chaleur de bromination (facteur de conversion 5.5 de Helner et Mitchell) sont légèrement plus faibles que ceux obtenus directement par la méthode de Hübl. Les résultats comparatifs figurent au Tableau 5.

TABLEAU 5—INDICE D'IODE ET CHALEUR DE BROMINATION

	Extrait gras sec, en gr.	Sol. N/10 $Na^2S^2O^3$ (fact. 0.905)	Indice d'iode trouvé	Chaleur de bromination	Indice d'iode calculé (coef. 5.5)
Grove City	0.500	20.2	46.41	8.2	45.10
Roquefort	0.505	23.0	52.33	9.0	49.50
Gorgonzola	0.420	17.2	47.05	8.5	46.75
Stilton	0.544	21.1	44.56	7.9	43.45

Détermination de la chaleur de bromination.—(Nouvelle technique applicable au fromage).

La méthode de Gill et Hatch préconisée pour l'examen des huiles et des beurres, donne des résultats constants et concordants lorsqu'on l'applique à l'extrait gras des fromages. Mais, comme l'extraction de la matière grasse est une opération de longue durée (12 à 14 heures), j'ai songé à établir une technique qui permettrait d'opérer directement sur le fromage. J'ai obtenu de bons résultats en procédant de la manière suivante. On pèse exactement une quantité de fromage correspondant à un gr. de matière grasse. On triture minutieusement ce fromage dans un mortier avec deux volumes de sable fin, calciné. On dépose le mélange sur le fond d'un tube à essai de 50 cc. On lave le mortier avec 15 cc. de $CHCl_3$ ou de CCl_4 ajoutés en deux fois. On introduit le liquide de lavage dans le tube sans toucher les parois de celui-ci. On mélange intimement avec une baguette de verre et on laisse reposer dans le colorimètre pendant 2 minutes. On ferme le tube à essai avec un bouchon muni d'un thermomètre très sensible, fixé de façon à ce que le bulbe plonge dans la solution qui surmonte le sable. On note la température au dixième près. On introduit alors 5 cc. de la solution habituelle de Br (4 volumes $CHCl_3$ ou CCl_4 + 1 volume Br) qu'on laisse couler sur les parois du tube. On bouche immédiatement et on mélange par quelques mouvements de rotation. On note exactement le maximum de température au dixième près. La différence entre les deux lectures, multipliée par 2, donne la chaleur de bromination, et cette dernière multipliée par le coefficient habituel 5.5, fournit l'indice d'iode.

Bien que le nombre des essais soit encore très restreint, je me suis permis d'exposer ici cette technique tout en demandant aux lecteurs de bien vouloir considérer la présente note comme une communication préliminaire, entendu qu'il faudra encore vérifier les résultats obtenus par des expériences faites sur un plus grand nombre de fromages. Le Tableau 6 résume les résultats obtenus et permet de faire les comparaisons nécessaires.

Tableau 6—Chaleur de bromination déterminée directement sur le fromage

	Pour cent de matière grasse	Poids de fromage en gr.	Température obtenue	Chaleur de bromination	Indice d'iode calculé	Indice d'iode trouvé
Grove City	31.25	3.200	4.2	8.4	46.2	46.41
Roquefort	31.20	3.205	4.9	9.8	53.9	52.33
Gorgonzola	30.81	3.245	4.3	8.6	47.3	47.05
Stilton	31.50	3.174	4.0	8.0	44.0	44.56

RESUME ET CONCLUSION

Une étude comparative de quelques fromages renfermant le *Penicillium glaucum* a été faite au point de vue (1) de la composition: eau-graisses-protéines-cendres; (2) de la teneur en acides gras volatils; (3) de l'indice d'iode et de la chaleur de bromination.

La recherche de l'indice d'iode et de la chaleur de bromination a fourni l'occasion d'élaborer une nouvelle technique qui permet d'opérer directement sur le fromage.

De l'ensemble des résultats obtenus, on peut tirer les principales conclusions suivantes.

1o—Le Grove City, le Stilton, le Roquefort et le Gorgonzola accusent sous le rapport des constituants bruts, une composition très voisine. Cependant le Roquefort se signale par une teneur notablement plus élevée en matières minérales. Ceci doit être attribué à deux faits: (a) le lait de brebis est plus riche en cendres que le lait de vache; (b) le Roquefort reçoit plus de NaCl au salage.

2o—Il existe une parallélisme frappant entre la teneur en acides gras volatils et l'intensité de la saveur. Au point de vue de l'intensité décroissante de cette dernière, les fromages étudiés se classent dans l'ordre: Grove City, Roquefort, Gorgonzola et Stilton. Considérés au point de vue des proportions décroissantes d'acides gras volatils totaux, ils conservent le même ordre. Ceci confirme la conclusion de James N. Currie "les acides caproique, caprylique, caprique et leurs sels facilement hydrolysables sont la cause de la saveur caractéristique du Roquefort" et permet d'étendre cette conclusion aux fromages Grove City, Gorgonzola et Stilton.

3.—Les acides gras volatils sont évidemment le résultat d'un processus hydrolytique, car aux chiffres élevés de l'acidité totale et de l'acidité ionique (par rapport au lait dépourvu d'acide lactique) correspondent des indices d'iode de la matière grasse, également élevés. L'augmentation comparativement plus grande de l'indice d'iode dans le cas du Roquefort est un fait normal, puisque les glycérides du lait de brebis contiennent plus d'acides à liaisons éthyléniques que ceux du lait de vache.

4.—Les chaleurs de bromination obtenues par la technique nouvelle donnent des indices d'iode concordants. En outre, ceux-ci se rapprochent davantage des chiffres trouvés par la méthode de Hübl, que ceux calculés d'après la chaleur de bromination de l'extrait éthéré des fromages.

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THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, LARGELY FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

Wholesale prices in Canada remained unchanged in November and December, 1934, the index being 71.2. One of the features of price conditions during the past year was the relative stability of wholesale prices. The index in January was 70.6 but rose to 72.3 in August and declined again to 71.2 in November. The index of wholesale prices of Canadian farm products rose from 55.3 in January to 61.6 in December; this represented a gain of more than 6 points.

Retail Prices.—The index number of retail prices was 78.2 in January and rose to 79.9 in March, after which it declined until June, when it again stood at 78.2. This was followed by a rise until November when it reached 79.4; the December index was 79.0. The index number of prices of foods was highest in March when it was 72.9 but fell to a low point of 67.6 in June from which it rose to 69.9 in November and receded to 69.3 in December.

Physical Volume of Business.—As this is being written, data for the physical volume of business in the month of December are not available. Comparison must, therefore, be made on the basis of the first eleven months of 1934. The index was at the low point of 86.8 in January, rose to 99.0 in August and declined to 95.5 in October. The November index was 96.5. Industrial production followed a somewhat similar course; the low point of 83.9 was registered in January. It rose to 99.9 in May, fell off again in June and July but was 99.8 in August; the November index was 97.0.

Mineral production has been substantially above the monthly average for 1926 throughout the eleven month period, reaching a high point of 160.2 in April. Similarly, in manufacturing, the low point was 86.2 in January, and in two of the succeeding months, May and August, this index rose above the monthly average for 1926. The figure for November was 96.0 as compared with 94.8 in October. Newsprint output has been at high levels during 1934. Production of iron and steel showed some improvement. Automobile output was much above that in 1933. Construction continued to improve but progress is not rapid. Agricultural marketings showed wide fluctuations being largely influenced by the movement of grains. The index of cold storage holdings was above that a year ago.

Agricultural Products.—Wholesale prices of Canadian farm products advanced from 55.3 in January to 61.6 in December. The index of prices of field products rose from 47.9 in January to 60.7 in August, declined to 55.3 in October and rose to 56.0 in December. Prices of animal products have been at somewhat higher levels. The low point was reached in August but there were substantial gains in September and October while prices were maintained in November and showed a slight gain in December. The general level of wholesale prices of Canadian farm products in 1934 averaged about 15% above that in 1933, but compared with the low point of the depression prices in December had advanced about 43%.

The index of agricultural marketings was 51.2 in November compared with 61.2 in the previous month, being largely influenced by grain marketings which declined from 57.9 in October to 46.2 in November, slower movement of wheat being largely responsible. There was a slight advance in the shipment of oats but marketings of other grains were quite low.

Hog marketings were higher in November than in October but there was a smaller movement of other live stock, particularly sheep and lambs. According to the live stock market report, 52,622 head of cattle were exported to Great Britain during 1934 compared with 53,006 in 1933. Domestic sales of cattle at public yards totalled 696,549 head in 1934 as against 602,537 in the previous year. Sales of calves were

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933	67.1	51.0	45.8	59.6	77.7	79.7	76.8	105.1	115.4
1933									
Jan.	63.9	43.6	35.1	57.9	79.1	68.1	62.2	56.1	112.0
Feb.	63.6	43.0	36.0	54.7	78.4	67.0	60.0	76.5	127.6
Mar.	64.4	44.7	38.0	56.0	77.8	68.4	62.5	129.0	135.8
April	65.4	46.8	41.1	56.4	78.0	69.8	65.1	104.1	112.7
May	66.9	51.2	46.9	58.4	77.0	76.4	72.7	95.4	110.4
June	67.6	52.6	49.4	57.9	77.0	82.2	79.8	221.9	119.9
July	70.5	60.1	60.8	59.0	77.2	84.1	82.6	221.9	119.9
Aug.	69.4	57.0	54.9	60.5	78.6	89.8	89.5	197.2	114.2
Sept.	68.9	54.7	49.5	63.4	78.5	90.8	90.2	101.1	115.7
Oct.	67.9	51.4	44.6	62.8	77.9	88.2	87.4	70.5	112.7
Nov.	68.7	53.8	46.7	65.8	78.1	85.5	83.9	41.8	111.1
Dec.	69.0	53.3	45.3	66.6	78.4	86.2	85.1	30.7	107.6
1934									
Jan.	70.6	55.3	47.9	67.8	78.2	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	78.7	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	79.9	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.4	92.6	91.4	56.9	94.5
May	71.1	56.9	51.1	66.5	78.5	99.6	99.4	130.6	102.6
June	72.1	59.3	55.5	65.6	78.2	95.8	95.2	97.2	126.1
July	72.0	60.0	57.8	63.7	78.4	95.7	95.6	148.8	116.3
Aug.	72.3	61.6	60.7	63.1	78.7	99.0	99.8	172.8	114.7
Sept.	72.0	61.3	58.9	65.3	79.0	97.1	97.5	127.7	117.7
Oct.	71.4	60.9	55.3	70.4	79.3	95.8	95.3	61.2	128.8
Nov.	71.2	61.2	55.7	70.4	79.4	96.5	97.0	51.2	130.4
Dec.	71.2	61.6	56.0	70.9	79.0	92.4	91.0	36.0	135.7

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1932, p. 32, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries. See Prices and price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

369,661 and 316,901 respectively. Sheep marketed numbered 458,608 during the past year compared with 471,217 in 1933. Hog gradings were 3,014,198 head in 1934 as against 3,170,582 graded in 1933.

Prices in United States.—Indexes of prices paid to farmers for farm products in United States (av. 1910–1914 = 100) in November as compared with October were as follows: grains 109, unchanged; cotton and cotton seed 107, unchanged; fruits 94, as compared with 98; truck crops 105, as against 100; chickens and eggs 125 and 108 respectively; meat animals 72 and 74; the total index was unchanged at 102. The ratio of prices paid to prices received remained at 81. The index of prices paid to farmers in United States was 77 in January; it rose to 84 in March but declined to 82 in May and June. It rose to 103 in September and was unchanged at 102 in October and November.

Prices in Great Britain.—Prices of agricultural produce in Great Britain (av. 1910–13 = 100) have shown improvement over 1933. During the past year, the low point was reached in March when the index was 108. It rose to 119 in August. It was unchanged in September and declined to 115 in October but in each of the first 10 months of 1934 the index was higher than in the corresponding month of 1933.

LA SITUATION ÉCONOMIQUE

PRÉPARÉ PAR LA DIVISION DE L'ÉCONOMIE AGRICOLE, MINISTÈRE DE L'AGRICULTURE, OTTAWA, PRINCIPALEMENT D'APRÈS LES DONNÉES RECUEILLIES PAR LE BUREAU FÉDÉRAL DE LA STATISTIQUE

Les prix de gros au Canada n'ont pas changé en novembre et en décembre 1934; l'indice était à 71.2. La stabilité relative des prix de gros a été l'un des faits caractéristiques de la situation l'année dernière. L'indice était à 70.6 en janvier, il s'est élevé à 72.3 en août pour retomber à 71.2 en novembre. L'indice des prix de gros des produits de fermes canadiens est passé de 55.3 en janvier à 61.6 en décembre; ceci représente un gain de plus de 6 points.

Prix de détail.—Le chiffre-indice des prix de détail était à 78.2 en janvier, il s'est élevé à 79.9 en mars, puis il a suivi une courbe descendante jusqu'en juin lorsqu'il s'est remis à 78.2. Il a monté ensuite jusqu'en novembre pour atteindre 79.4; l'indice de décembre était à 79.0. Le chiffre-indice du prix des aliments était à son plus haut point en mars, à 72.9, puis il est retombé au bas point de 67.6 en juin d'où il s'est relevé jusqu'à 69.9 en novembre pour retomber à 69.3 en décembre.

Volume physique des affaires.—Nous n'avons pas, au moment où nous écrivons ces lignes, les données relatives au volume physique des affaires pour le mois de décembre, et la comparaison ne peut donc être faite que sur la base des premiers onze mois de 1934. L'indice était au bas point de 86.8 en janvier, il s'est élevé à 99.0 en août pour retomber à 95.5 en octobre. L'indice de novembre était à 96.5. La production industrielle a suivi une courbe à peu près semblable; le bas point de 83.9 a été enregistré en janvier; l'indice s'est élevé à 99.9 en mai pour retomber à nouveau en juin et en juillet, mais il était à 99.8 en août; l'indice de novembre était à 97.0.

La production minérale a été sensiblement plus élevée que la moyenne mensuelle pour 1926 pendant la période de onze mois, atteignant un haut point de 160.2 en avril. Il en a été de même dans l'industrie manufacturière; le bas point était de 86.2 en janvier et dans deux des mois suivants, mai et août, cet indice s'est élevé au-dessus de la moyenne mensuelle de 1926. L'indice de novembre était à 96.0 contre 94.8 en octobre. La production du papier-journal est restée à un niveau élevé en 1934. La production du fer et de l'acier a fait quelques progrès. Celle des automobiles était bien supérieure au chiffre de 1933. L'industrie du bâtiment a continué à s'améliorer, mais le progrès n'est pas rapide. Les ventes de produits agricoles présentaient de grandes fluctuations; elles étaient surtout influencées par le mouvement des grains. L'indice des stocks conservés au froid était supérieur à celui de l'année dernière.

Produits agricoles.—Les prix de gros des produits de fermes canadiens, qui étaient à 55.3 en janvier, sont montés à 61.6 en décembre. L'indice des prix des produits des champs s'est élevé de 47.9 en janvier à 60.7 en août; il est retombé à 55.3 en octobre pour remonter à 56.0 en décembre. Les prix des produits animaux étaient à un niveau un peu plus élevé. Le bas point a été atteint en août, mais il y a eu une hausse considérable en septembre et en octobre, et les prix se sont maintenus en novembre et légèrement relevés en décembre. En 1934, le niveau général des prix de gros des produits de fermes canadiens était en moyenne d'environ 15% supérieur à celui de 1933, mais il avait monté d'environ 43% par comparaison au bas point de la dépression en décembre.

L'indice des ventes agricoles était à 51.2 en novembre contre 61.2 le mois précédent, en raison de la diminution des ventes de grain, qui, de 57.9 qu'elles étaient en octobre sont tombées à 46.2 en novembre, surtout à cause du ralentissement des expéditions de blé. Il y a eu une légère augmentation dans les expéditions d'avoine mais les ventes des autres grains ont été très faibles.

Il s'est vendu plus de porcs en novembre qu'en octobre, mais par contre les expéditions d'autres bestiaux, et surtout de moutons et d'agneaux, ont été moins considérables. Le rapport du commerce des bestiaux nous apprend qu'il s'est exporté sur la Grande-Bretagne en 1934, 52,622 bovins contre 53,006 en 1933. Les

ventes domestiques de bovins aux marchés publics ont atteint un total de 696,549 têtes en 1934 contre 602,537 l'année précédente. Le nombre des veaux vendus était de 369,661 et de 316,901, respectivement. Les ventes de moutons se chiffraient par 458,608 têtes l'année dernière, contre 471,217 en 1933. Le nombre de porcs classés a été de 3,014,198 têtes en 1934 contre 3,170,582 en 1933.

Prix aux Etats-Unis.—L'indice des prix payés aux cultivateurs des Etats-Unis pour les produits de la ferme (moyenne 1910-1914 : 100) en novembre par comparaison à octobre, était le suivant:—grains 109, aucun changement; coton et graine de coton 107, aucun changement; fruits 94, contre 98; récoltes maraîchères 105, contre 100; poulets et œufs 125 et 108, respectivement; animaux de boucherie 72 et 74; l'indice total qui était à 102 n'accusait aucun changement. Le rapport entre les prix payés et les prix reçus est resté à 81. L'indice des prix payés aux cultivateurs des Etats-Unis était à 77 en janvier, il s'est élevé à 84 en mars mais est retombé à 82 en mai et juin. Il s'est élevé à 103 en septembre et est resté à 102 en octobre et novembre.

Prix en Grande-Bretagne.—Les prix des produits de ferme en Grande-Bretagne (moyenne 1910-13 : 100) se sont améliorés par comparaison à 1933. L'année dernière, le bas point avait été atteint en mars lorsque l'indice était à 108. Il s'est élevé à 119 en août. Il est resté au même point en septembre pour retomber à 115 en octobre, mais dans chacun des dix premiers mois de 1934, l'indice était plus élevé que pour le mois correspondant de 1933.